

HOUSTON AIRPORT SYSTEM DESIGN STANDARDS MANUAL

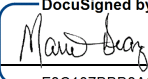


2023 Edition

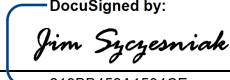
**HOUSTON AIRPORT SYSTEM
DESIGN STANDARDS MANUAL
2023 Edition**




Approval page

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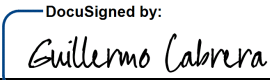
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01 - INTRODUCTION



01 – Introduction

1.1 Background

- 1.1.1.** The Houston Airport System (HAS) Design Standards encompass general guidelines and specific technical criteria for the design and construction of all facilities owned, operated or maintained by HAS for both new construction and renovation of existing facilities. The Design Standards will apply to all construction projects within the boundaries of:
- 1.1.1.1.** **George Bush Intercontinental Airport (IAH)**, with nearly 200 non-stop destinations on 29 airlines. In 2015, 43 million passengers traveled through IAH.
- 1.1.1.2.** **William P. Hobby Airport (HOU)** has nearly 60 non-stop destinations on five airlines. In 2015, more than 12 million passengers traveled through HOU.
- 1.1.1.3.** **The Houston Spaceport (EFD)** Former Ellington Airport which supports the United States Military, National Aeronautics and Space Administration (NASA), and a variety of general aviation tenants. EFD, and is the nation’s 10th licensed commercial spaceport.
- 1.1.2.** The Design Standards were created by a HAS working group consisting of asset management, operations, maintenance, and technology personnel. The Standards are based on lessons learned from prior capital improvement projects and design criteria developed for infrastructure and renovation projects.
- 1.1.3.** The Design Standards form a “living” document that will be updated as design criteria, referenced codes, and standards change due to improved materials, methods, or decisions from technical evaluations that arise.

1.2 Purpose

- 1.2.1.** The purpose of the Design Standards is to guide the airport development projects in support of:
- 1.2.1.1.** The HAS Vision to “Establish the Houston Airport System as a five-star global air service gateway where the magic of flight is celebrated.”
- 1.2.1.2.** **The HAS Mission:** “We exist to connect the people, businesses, cultures and economies of the world to Houston.”
- 1.2.1.3.** **HAS Strategic Priorities consist of:**
- Make our passengers happy;
 - Achieve “Opening Day Fresh” condition for our airports;
 - Build the platforms for future success; and
 - Invest in our partnerships and our employees.
- 1.2.1.4.** **HAS Core Values**
- **Relationships:** We work together with integrity and treat every individual with courtesy and respect.
 - **Innovation:** We have the courage and willingness to consider new and unconventional ways of thinking.
 - **Service:** We “WOW” our passengers through a “can do” attitude and respond quickly to meet and exceed their expectations.
 - **Excellence:** We strive for quality and skillful execution without compromise.

1.2.1.5. Sustainable Management Plan (SMP) outlines HAS's commitment to provide world-class airport operations, commitment to being operational efficient, and determination to become more sustainable. The SMP provides a road map for advancing sustainability successes and improving overall operational efficiency within the framework of goals, summarized below, and supporting actions, such as the development of this Sustainable Design Standard Manual.

- **Solid Waste and Recycling:** Increase the landfill diversion rate at IAH and HOU by five (5) percent per year.
- **Solid Waste and Recycling:** For any new construction or renovation at IAH and HOU over the next 10 years, design and build to provide waste/recycling infrastructure that promotes a culture of recycling.
- **Energy:** Reduce energy use at IAH and HOU by five (5) percent per year. For any new construction or renovation at IAH and HOU over the next 10 years, design and build to achieve a minimum improvement of 20 percent energy performance over the most current version of the local energy code.
- **Water:** Reduce potable water use by five (5) percent by 2025.
- **Greenhouse Gases:** Quantify and track greenhouse gas emissions as a performance indicator of energy and solid waste/recycling performance.
- **Sustainable Design:** Incorporate SMP goals into HAS design guidance by the end of 2018.
- **Sustainable Assets and Infrastructure:** Track the reliability and condition of infrastructure assets to support informed business decisions.
- **Sustainable Procurement:** Ensure 100 percent of HAS contractors demonstrate a commitment to sustainability by 2024.
- **Enhanced Commissioning:** As an integral part of the Sustainability Master Plan provide enhanced commissioning to improve design, installation and performance of building systems to ensure proper installation, maximize performance of building enclosures and mechanical, electrical and plumbing systems, and provide continuous commissioning support to optimize energy savings and lower maintenance cost for the life of the building. The commissioning authority shall participate in the early design development process and construction. This includes all energy and water consuming systems and the building envelope.
- **Solar Ready:** The design team shall identify on the plans a pathway from the roof to the electrical room to accommodate a solar installation in the future. They shall also verify the roof design will accommodate the weight of the panels in the future with as much open space on the roof as possible for future panel installation. Space is to be allocated in the electrical room to accommodate solar tie into the system in the future.

1.2.2. Individuals who will use these Design Standards include, but are not limited to, design consultants, contractors and HAS project management teams responsible for planning, designing, and constructing capital improvement projects. It is not the intent of the Design Standards to limit or dismiss the experience or creativity of design consultants, but rather to identify preferred methods and materials of construction; therefore, promoting projects to be designed with a consistent approach that best meets or exceeds the HAS Strategic Priorities.

1.2.3. The Design Standards are not intended to define all design features and principles, but rather to provide guidance applicable to HAS, which has specific needs that must be met. Design consultants are always expected to incorporate principles of sound design practice.

1.2.4. Designer to specify that any operable piece of equipment or system, as applicable, be capable of being integrated with an enterprise Building Management System so that real-time information

can be accessible to HAS and as applicable, to passengers.

1.3 Content Organization

- 1.3.1.** Content for the Design Standards is organized by the OmniClass Construction Classification System (known as OmniClass™ or OCCS). OmniClass™ is a means of organizing and retrieving information specifically designed for the construction industry. OmniClass™ can be used for many applications, such as organizing library materials, product literature, asset management, and project information. OmniClass™ incorporates other systems in use to form the basis of its Volumes wherever possible — MasterFormat™ for work results, UniFormat™ for elements, and EPIC (Electronic Product Information Cooperation) for structuring products.
- 1.3.2.** OmniClass™ is designed to provide a standardized basis for classifying information created and used by the North American Architectural, Engineering and Construction (AEC) industry. Throughout the full project life cycle, from “cradle to grave,” OmniClass™ encompasses all the different types of construction that make up the built environment. OmniClass™ is intended to be the means for organizing, sorting, retrieving information, and deriving relational computer applications.

1.4. Standards Content Organization

- 1.4.1.** Establishing OmniClass™ as a framework for organizing the Standards, HAS adopted 14 of the available 15 OmniClass™ tables to use as placeholders for current and future development. These placeholders, defined as Volumes, provide a guide for future expansion of the Standards.
- 1.4.2.** The basis of the current Standards encompasses Volumes 10 (Disciplines), 13 (Information), and general criteria sections. Volume 10 aligns with the proprietary system for the HAS Asset Management Database, while Volume 13 addresses HAS Computer-Aided Design (CAD) Standards, HAS Building Information Modeling (BIM) Standards, Commissioning, and Activation that are already in place or soon to be adopted.
- 1.4.3.** OmniClass™ is a comprehensive classification system for the construction industry. OmniClass™ is designed to encompass objects at every scale through the entire built environment, from completed structures, vast projects, and multi-structure complexes to individual products and component materials. It is designed to address all forms of construction, vertical and horizontal, industrial, commercial and residential. OmniClass™ also addresses actions, people, tools, and information that are used or take part in the design, construction, maintenance, and occupancy of these facilities.
- 1.4.4.** OmniClass™ incorporates other extant systems currently in use as the basis of some of its Tables — such as MasterFormat™ for work results and UniFormat™ for elements.
- 1.4.5.** Class™ is a strategy for classifying the entire project environment.
- 1.4.6. HAS and OmniClass™ Benefits:**
- OmniClass™ is vertically and horizontally expandable, every piece of Standards content can find a category within the system.
 - Future Volumes will have an already established structure, eliminating the need for conflict resolution between different documents.
- 1.4.7.** The information exchange between HAS and other peers is more efficient.
- 1.4.8.** OmniClass™ is compatible with MasterFormat™ and UniFormat™. There is no need to restructure current HAS documents and other Standards.

1.5 Document Management

- 1.5.1.** The proposed framework for the Standards provides opportunities to continually enhance and expand the content over time. The HAS Infrastructure Division will continually enhance the process of HAS growth in project types and changing operations that drive the Standards. The goal of this “living document” is to maintain existing information and provide an efficient framework for incorporating newer design criteria in the future. As information is gathered from future design and construction projects, HAS will review the applicability of incorporating new information or creating new documents in the pre-defined Volumes. Where appropriate, design consultants, contractors, and vendors are encouraged to recommend alternatives when deviations from the Standards appear to be beneficial to a project. There is a Governance Procedure to promote and encourage creativity and introduce new technology.
- 1.5.2.** Refer to the Standards Governance Procedure section for a description of the variance and change request procedures.

02 - GOVERNANCE PROCEDURE



02 - Governance Procedure

1.1. HAS Design Standards Document Management

- 1.1.1.** The Houston Airport System (HAS) Infrastructure Division will manage the content and update this document periodically to continually enhance and expand the content over time. The goal of this “living document” is to maintain existing information and provide an efficient framework for incorporating newer design criteria in the future. As information is gathered from future design and construction projects, HAS will review the applicability of creating, revising, or replacing content to address new technologies, materials and methods.
- 1.1.2.** The Asset Engineering Department within the HAS Infrastructure Division will be responsible for evaluating and recommending approval to the Change Review Committee (CRC).
- 1.1.3.** Change or variance requests may be initiated from the following groups:
- HAS Internal Teams
 - Airlines
 - Consultants, Contractors, and Vendors
 - Governmental Agencies

1.2 Change Management Submittal Process

- 1.2.1.** The Design Standards governance procedure, as described in this section, addresses the change management process and how change will be implemented and applied to the Design Standards.
- 1.2.2.** Change will be implemented by variance and change requests.
- 1.2.2.1.** Variance Requests will be submitted, in writing, by Consultants, Contractors, Airlines, and Vendors to address a project-specific change.
- 1.2.2.2.** Change Requests will be submitted by the HAS Project Manager to the applicable Asset Engineer to address permanent revisions to the Standards.

1.3 Change Management Approval Process (CMA)

1.3.1. For Variance Requests:

- 1.3.1.1.** The CMA process may occur at any time during project delivery. The HAS Project Manager will present a Variance Request to the appropriate Asset Engineering representative for recommendation at an HAS Construction Review Committee (CRC) meeting.
- 1.3.1.2.** The HAS Project Manager is responsible for submitting a Variance / Change Request Form. The form will include all supporting documentation from the variance request initiator for consideration of the proposed variance to a Project. Supporting documentation may include; but is not limited to:
- Rationale for the variance request including specific benefits the proposed variance may provide and how it will be implemented.

- Enhancement of operations, durability, warranty, and ease of maintenance to support the proposed variance, including:
- Catalog Cut Sheets
- Drawings
- Samples
- Schedule Benefits
- Life Cycle Cost Benefits

1.3.1.3. Reference Appendix Section 1.5, Appendix A and B

1.3.2. For Change Requests:

1.3.2.1. The CMA process may occur periodically to modify an existing Design Standard or to recommend adoption of a new Design Standard. The Asset Engineer will present a change request for recommendation at a CRC meeting.

1.3.2.2. The Asset Engineer is responsible for submitting a Variance / Change Request Form all supporting documentation for consideration of the proposed change. Supporting documentation may include; but is not limited to: Rationale for the change request including specific benefits as to why the change is proposed and how it will be implemented.

- How enhancement of operations, durability, warranty, and ease of maintenance will help to support the proposed change.
- Catalog Cut Sheets
- Life Cycle Cost Benefits

1.3.2.3. Reference Appendix Section 1.5, Appendix A and B.

1.4 Standards Content Organization

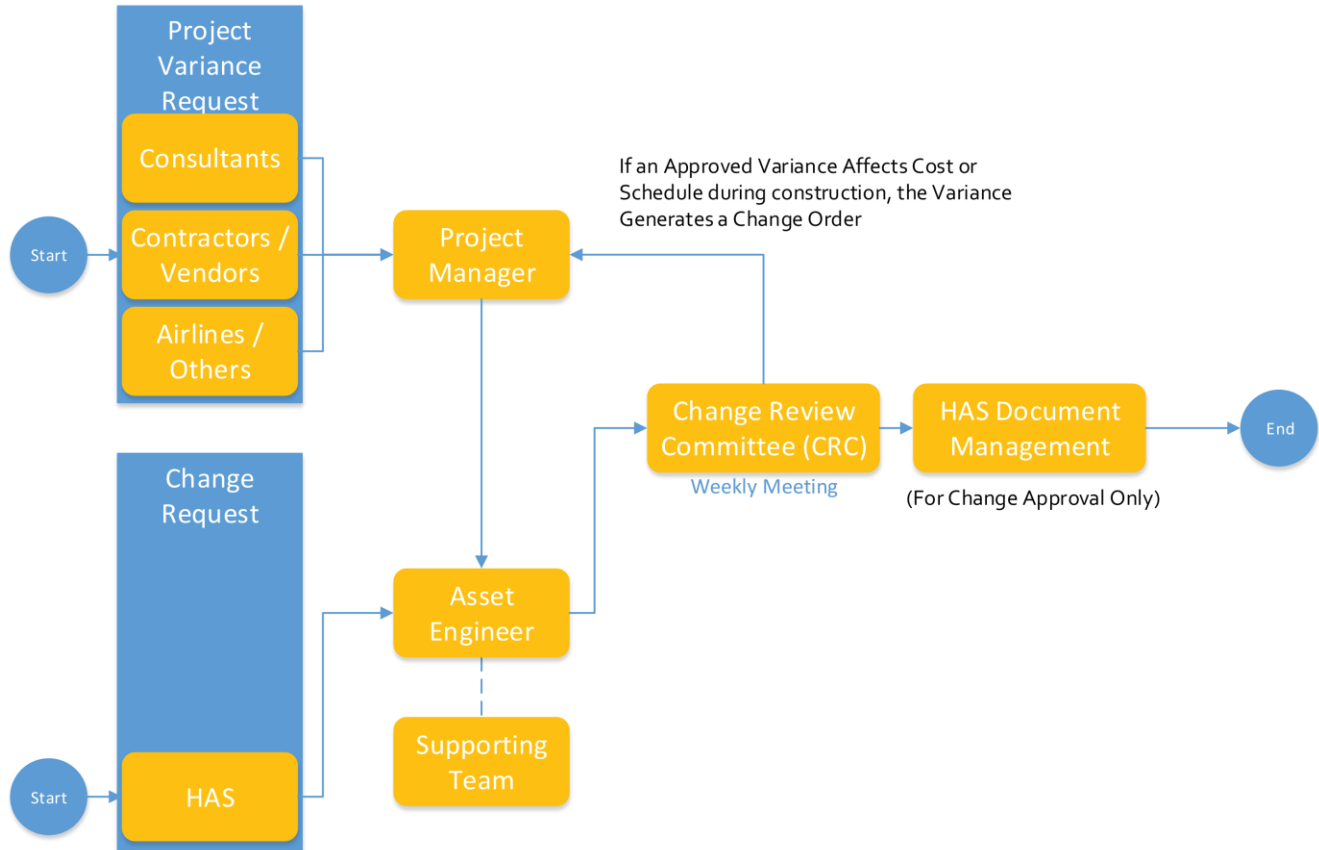
1.4.1. HAS adopted the OmniClass™ Construction Classification System as a framework for organizing the HAS Design Standards. HAS adopted 14 out of the available 15 OmniClass™ tables to use as placeholders for current and future development. These placeholders, defined herein as “Volumes”, provide a road map for future expansion of the Standards.

1.4.2. The basis of the Design Standards encompasses Volumes 10 (Disciplines), 13 (Information), and general criteria sections. Volume 10 aligns with the proprietary system for the HAS Asset Management Database, while Volume 13 addresses HAS CAD standards, HAS Building Information Modeling (BIM) standards, commissioning, and activation that are already in place or soon to be adopted.

1.4.3. Reference Section 1.5, Appendix C.

1.5 Change Management Forms

Exhibit 1.5-1: Appendix A – Project Variance / Change Request



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Exhibit 1.5-2: Appendix B – Variance / Change Request Form



Variance / Change Request Form

Date: _____
Project Name: _____
Project No.: _____

Standard from which Variance / Change is requested
Section Name: _____
Page No.: _____
Notes:

HAS Representative (PM or Asset Engineer): _____
Contact: _____
Telephone: _____

Reason for Variance / Change: *(attach additional sheets as required)*

Consultant: _____
Contact: _____
Telephone: _____

If appropriate, attach specifications, catalog cut sheets and submit samples.

FOR HAS USE

Contractor / Vendor / Other: _____
Contact: _____
Telephone: _____

APPROVED [] **Notes:**
APPROVED AS NOTED []
REJECTED []

 HAS Signature Authority Date



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Exhibit 1.5-3: Appendix C - OmniClass™

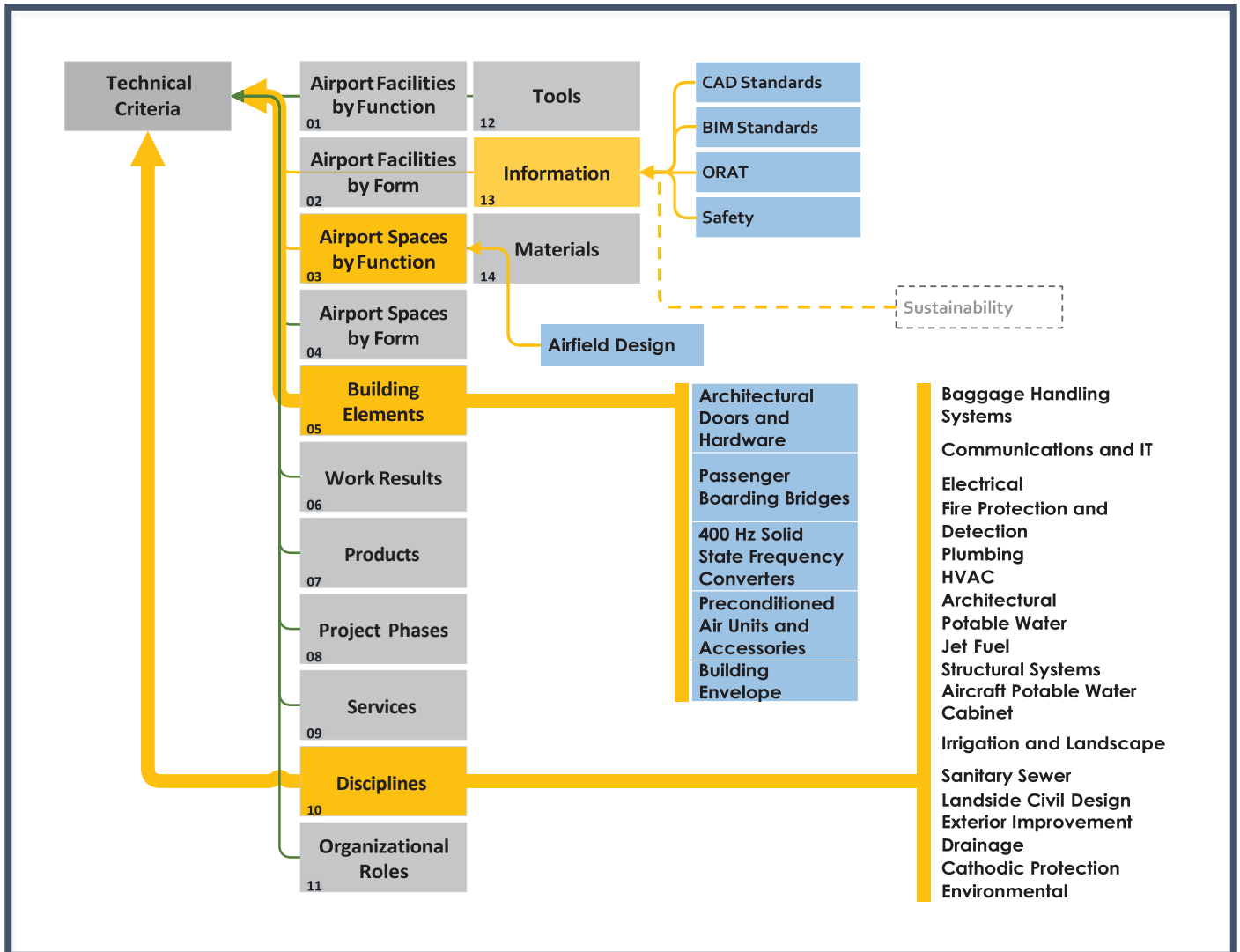
Volume (Adapted from OmniClass™)	Definition	Examples
Airport Facilities by Function	Construction entities by function are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by function.	Single Family Residences, Mining Facility, Local Transit Bus Station, Interstate Highway, Waste Water Treatment Facility Freezer Storage Facility, Department Store, Courthouse, Hotels, Convention Center
Airport Facilities by Form	Construction entities by form are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by form.	High-Rise Buildings, Suspension Bridge, Platform, Space Station
Airport Spaces by Function	Spaces by function are basic units of the built environment delineated by physical or abstract boundaries and characterized by function.	Kitchen, Mechanical Shaft, Office, Highway
Airport Spaces by Form	Spaces by form are basic units of the built environment delineated by physical or abstract boundaries and characterized by physical form.	Room, Alcove, Cavity, Courtyard, Easement, City Block
Building Elements	An Element is a major component, assembly, or "construction entity part which, in itself or in combination with other parts, fulfills a predominating function of the construction entity" (ISO 12006-2). Predominating functions include, but are not limited to, supporting, enclosing, servicing, and equipping a facility. Functional descriptions can also include a process or an activity.	Structural Floors, Exterior Walls, Storm Sewer Utility, Stairs, Roof Framing, Furniture and Fittings, HVAC Distribution
Work Results	Work results are construction results achieved in the production stage, phase, subsequent alteration, maintenance, or demolition processes, and identified by one or more of the following: the particular skill or trade involved; the construction resources used; the part of the construction entity which results; the temporary work, other preparatory, or completion of work which is the result.	Cast-in-Place Concrete, Structural Steel Framing, Finish Carpentry, Built-Up Bituminous Waterproofing, Glazed Aluminum Curtain Walls, Ceramic Tiling, Hydraulic Freight Elevators, Water-Tube Boilers, Interior Lighting, Railways
Products	Products are components or assemblies of components for permanent incorporation into construction entities.	Concrete, Common Brick, Door, Metal Window, Junction Boxes, Pipe Culverts, Cast-Iron Boiler, Curtain Walls, Textured Paints, Vinyl-Coated Fabric Wall Covering, Demountable Partitions, Pre-Engineered Manufactured Structures

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Volume (Adapted from OmniClass™)	Definition	Examples
Project Phases	<p>Life cycle phases are often represented by two terms used somewhat interchangeably in our industry. For the purposes of clarity and standardization, OmniClass™ offers two specific definitions for their usage in tables:</p> <p>Stage: A categorization of the principal segments of a project. Stages usually are: conception, project delivery selection, design, construction documents, procurement, execution, utilization, and closure.</p> <p>Phase: A portion of work that arises from sequencing work in accordance with a predetermined portion of a Stage. For purposes of usage in OmniClass™ classifications, a Stage is a higher-level of categorization and a Phase is a subordinate level of titling within a Stage.</p>	Conception Stage, Schematic Design Phase, Bidding Phase, Construction Phase, Occupancy Phase, Decommissioning Phase
Services	Services are the activities, processes, and procedures relating to the construction, design, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the life cycle of a construction entity.	Designing, Bidding, Estimating, Constructing, Surveying, Maintaining, Inspecting
Disciplines	Disciplines are the practice areas and specialties of the actors (participants) that carry out the processes and procedures that occur during the life cycle of a construction entity.	Architecture, Interior Design, Mechanical Engineering, General Contracting, Electrical Subcontracting, Legal, Finance, Real Estate Sales
Organizational Roles	Organizational roles are the functional positions occupied by the participants, both individuals, and groups that carry out the processes and procedures which occur during the life cycle of a construction entity. Table 34 can be combined with Table 33 - Disciplines, to provide a full classification of each participant in the creation and support of a facility. Table 33 and 34 – Where are those? We should point them in the right direction.	Chief Executive, Supervisor, Owner, Architect, Cost Estimator, Facility Manager, Specifier, Contractor, Administrative Assistant, Equipment Operator, Apprentice, Team, Committee, Association
Tools	Tools are the resources used to develop the design and construction of a project that do not become a permanent part of the facility. This includes computer systems, vehicles, scaffolding, and all other items needed to execute the processes and procedures relating to the life cycle of a construction entity.	Computer Hardware, CAD Software, Temporary Fencing, Backhoe, Tower Crane, Site Drainage Equipment, Formwork, Hammer, Light Truck, Site Hut
Information	Information is data referenced and utilized during the process of creating and sustaining the built environment.	Reference Standards, Periodicals, CAD Files, Specifications, Regulations, Construction Contracts, Lease Documents, Title Deeds, Catalogs, Operation and Maintenance Manuals
Materials	Materials are substances used in construction or to manufacture products and other items. These substances may be raw materials or refined compounds and are considered subjects of this table irrespective of form.	Metallic Compounds, Rocks, Soils, Timber, Glass, Plastics, Rubbers

Exhibit 1.5-4: Appendix D - Standard Content Organization



END OF SECTION

03 - DESIGN PROCESS OVERVIEW



03 - Design Process Overview

Part 1 – General

1.1. Introduction

- 1.1.1.** This Standard describes the administrative requirements and minimum deliverables of the Designer (Consultant) for capital improvement program (CIP) projects managed by the Houston Airport System (HAS) on HAS-owned facilities.

1.2. Design Progression

- 1.2.1. Project Initiation:** At the beginning of every design project, a pre-design conference will be scheduled to be attended by the project manager, contract administrator, other HAS representatives and pertinent members of the design team. During this meeting, discussion will include the program for the design, applicability of the Sustainable Design Matrix, the project budget and the project schedule as well as any other stakeholder issues and operational considerations that may impact the design, the project phasing, or special requirements to maintain service during construction.
- 1.2.2. Design Milestones:** Design review submittals are required at Schematic (30%), Design Development (60%), Construction Documents (95% and 100% final sealed Construction Documents) levels of completion. This Standard provides minimum information on the requirements and level of detail required for each of these submittals.
- 1.2.3. Project Review:** Normally, two weeks must be allowed for HAS staff review of each submittal. However, additional time maybe required under certain circumstances, particularly if there are interfaces with other projects, or if outside agency approvals are necessary. The Project Contract will dictate the delivery and review timeframes.
- 1.2.4. Review Comments:** The Designer must respond to all review comments. Copies of these responses will be turned in to the HAS Project Manager with the next submittal or as directed. Review comments provided in writing or noted directly on the submitted drawings must be referenced in the Project Report. The Project Report must accompany each submission. The response must be described in sufficient detail, as required by the Project Manager, to determine that the issue has been adequately addressed. Submittals made without addressing the previous comments will be considered incomplete.
- 1.2.5. Designer Participation During Bidding:** The following process is generally followed in the selection of contractors under design-bid-build (competitive sealed proposals) delivery method. Construction bids are solicited through general advertisements. A pre-bid conference is conducted prior to the final submission and opening of the bids to discuss the scope of work and answer questions from bidders. The pre-bid conference may include the Designer and HAS Project Manager hosting a tour of the project site. The Designer is expected to conduct or participate in this conference to provide answers to pertinent questions and to assist in preparing any resulting contract addenda. At the advertised time, the bids that have been received will be opened and read in accordance with the City of Houston (COH) procedures. The Designer typically will be asked to assist in analyzing the bids to determine the responsive low bidder. A notice to proceed with construction will be issued after City Council approval of the construction

contract, appropriation of the funds necessary to complete the project, and execution of the construction contract by the Mayor. If an alternative delivery method is selected for an individual project, the selection process will be qualification based and essentially follow that described for selection of the Designer.

1.2.6. Designer Participation during Construction: Prior to the start of construction, a pre-construction conference is held to review contract requirements, operational and site restrictions, sustainable design commitment notification procedures, and required inspections. Depending upon contract scope requirements, the Designer may be responsible for assisting in the review of shop drawings, submittals, change orders, and other documents. The Designer may also be required to attend periodic or regular construction progress meetings. On some projects, partnering sessions may be conducted. HAS representatives, the Designer, the Contractor and/or the Construction Manager, the major sub-contractors, and interested stakeholders will be included in the partnering sessions.

1.2.7. Designer Participation at Completion of Construction: Depending upon contract requirements, the Designer generally participates in a final project walk-through at completion of construction. The Designer is usually responsible for reviewing the Contractor's certified as-built drawings, specifications submittal, and for preparing the final record drawings.

Part 2 - Design Deliverables

2.1. Project Design Delivery

2.1.1. Production and maintenance of project documentation will comply with the HAS computer-aided design (CAD)/Geospatial Data Standards and Procedures Manual and the HAS building information modeling (BIM) Standards. During the design and construction stage of a project, the Designer will supply information and documentation as required by HAS. HAS will provide appropriate forms and instructions for the Designer and Contractor to utilize for submissions. Final deliverables will consist of the construction Contract Documents which will be complete and will set forth in detail all work required for a project's specific scope. This includes, but is not limited to:

- Architectural
- Civil
- Structural
- Mechanical
- Plumbing
- Electrical
- Fire protection and fire detection
- Communication
- Security and utility service systems
- Transportation interfaces
- Site work
- Sustainable design compliance
- All necessary bidding information

2.2. Required Submittals

- 2.2.1.** During the planning and design stages of project development, certain submittals are required in bound form for review and approval. The submittals described below are the minimum. Intermediate reviews may be required only if the scope of the project has been changed or if an earlier review found the drawings and specifications unacceptable, either as a whole or in part. The required state of completion of the drawings and specifications are as outlined herein. For each major element, at each stage of development, it is essential that the Designer address the existing systems and whether they intend to:
- 2.2.1.1. Install system extensions identical to the existing system;
 - 2.2.1.2. Install a system that is compatible with the existing system, meaning that the project includes all programming or adjustment to the existing system necessary to ensure compatibility; or
 - 2.2.1.3. Propose a complete system change that includes not only installation associated with the current project but replacement of the entire system, including all ancillary systems that currently are interfaced.
- 2.2.2.** Replacement will only be considered if accompanied by cost-benefit and life-cycle cost analyses that support the proposal. Likewise, for any change that requires reprogramming or other adjustments to the existing system, a life-cycle cost analysis will be required to support the proposal.
- 2.2.3.** Prior to any construction or design of grant funded projects, a detailed survey plan as required by Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5300-16 or later, must be submitted and approved by FAA and the National Geodetic Survey (NGS). All reports and approvals required by FAA will be submitted as specified in AC 150/5300-16, and -18 or later.

2.3. Project Report

- 2.3.1.** The Project Report is both the link between the budget concept requirements of the CIP definition phase and final design as well as a record of the project's progress through all design stages to final construction documents. It shall be prepared by the designer in coordination with the HAS Asset Engineer and Project Manager. A well developed and complete report is essential to:
- Provide a basic source on necessary data and cost estimates regarding proposed work required to support project goals and objectives.
 - Describe a functional need.
 - Provide a comprehensive justification of the need for the proposed project including, but not limited to, a life-cycle cost analysis.
 - Provide the analysis of the reasonable alternatives to accommodate the need.
 - Provide the criteria that are the basis for the preparation of contract documents, a preliminary project schedule, project scope, and associated budget.
 - Define the design and construction elements, e.g. delivery method, number of design/construction packages, suggested or required project milestones, etc.
- 2.3.2.** Throughout this Standard there will be references to elements that will be added to the Project Report, such as the Geotechnical Reports, surveys, facilities conditions assessment studies, environmental report, or other various reports or calculations. These elements are added for the purpose of building up the history of a project's development while maintaining focus on the functional need it is designed to address. In cases where industry, economic, or demand

changes require a change in the goals and therefore a change in the objectives of a project, those will also be documented so that the Designer can continue to focus on the need that the project is designed to address and the current objectives that need to be satisfied. It is very important that this Project Report be maintained as a living document, whether it is required for submission to the Federal Aviation Administration (FAA), as is required for CIP projects, or whether the project is funded solely by HAS funds.

- 2.3.3.** Certain HAS CIP project contracts may require the Designer to produce a Basis of Design submittal as part of the design stage deliverable. The Basis of Design encompasses elements of the Project Report with a narrative description of all components of a project's design.
- 2.3.4.** For projects requiring the construction of two or more major building systems (structural, plumbing, electrical, or HVAC) the Sustainable Design Matrix must be included in the Project Report and applicable asset category credits pursued and documented.

2.4. Design Calculations

- 2.4.1.** Most design projects require that various engineering calculations be performed, and/ or design criteria/material cut sheets be assembled. The calculations and cut sheets will provide the basis for information on the construction drawings and specifications. These values and calculations will be assembled in the Project Report. These documentation requirements will vary for each specific design discipline.

2.5. Schematic Design Stage

- 2.5.1. Schematic Design Stage (30%):** For all HAS Projects the schematic drawings (30%) design, and specifications will include the items listed below.
 - 2.5.1.1.** A boundary survey and/or site topographic survey will be made of the ground of the proposed building or construction site. All points will be tied to the existing Airport Coordinate System using the appropriate Survey Handbook for the subject airport. Ground survey verification of existing utility alignments and flow lines is required unless specifically exempted by the City Engineer.
 - 2.5.1.2.** All existing buildings, facilities, contours, roadways, utilities, signs in the immediate area of the project site, or relevant to the proposed work must be shown on a preliminary site plans and/or demolition plans.
 - 2.5.1.3.** Layouts of the proposed roadways, access drives, parking areas, site utilities, and building locations must be shown.
 - 2.5.1.4.** The Project Report is built upon the Project Development Brochure which indicates the objective of the project. The objective includes articulated goals and objectives; the applicable design standards; any specific design conditions imposed by HAS or other regulatory agencies; any conditions imposed by a "Record of Decision" or mitigation measures articulated in a "Finding of No Significant Impact". The Design Brochure also includes any proprietary specification or specifications written around a single manufacturer's product or any specifications naming a manufacturer or manufacturers of acceptable products, along with a justification for the non- competitive selection. Exceptions include products that are on a pre-approved listing published by the FAA or a listing of repurchased materials or products that were competitively selected by HAS with guaranteed prices for the project, so that prior approval of the City Engineer and/or the FAA

can be obtained, etc. This Project Report will be supplemented throughout the project and will become the official complete record of the project.

2.5.2. Schematic drawings and specifications for Airfield Projects will include the items listed below.

- 2.5.2.1. All existing terminals, runways, taxiways, taxilanes, aprons, vehicle service roads delineated on airfield elements, ground support equipment areas, emergency roads, buildings and structures, contours, underground utilities, signs in the immediate area of the project site or relevant to the proposed work must be shown. Identify the outfall number for drainage from the Airport Stormwater Drainage Master Plan.
- 2.5.2.2. All existing FAA Navigational Aids (NAVAIDs), duct banks, guidance signs, lighting fixtures, electrical ducts, vaults, hand holes, and circuit locations must be shown and identified.
- 2.5.2.3. Layouts of proposed paving, drainage, and electrical improvements including stationing, coordinates, and dimensions.
- 2.5.2.4. Limits and dimensions of all object free areas, safety areas, exclusion zones, NAVAIDS, critical areas, and FAR Part 77 airspace surfaces that affect project site.
- 2.5.2.5. Locations of proposed buildings, signs, NAVAIDS, air operations area (AOA) fences, and other site structures.

2.5.3. Schematic drawings and specifications for buildings will include:

- 2.5.3.1. Building code summary on cap sheet showing governing codes and requirements for building and site, including TAS/ADA, egress plans, etc.
- 2.5.3.2. Floor plans showing dimensions and square footage of usable areas
- 2.5.3.3. Elevations showing heights and planned access for items that are important to future maintenance of the facility
- 2.5.3.4. Location of chases, shut-off valves, clean outs, and other facility elements that are important in the future maintenance of the facility
- 2.5.3.5. Schedule of materials to be used
- 2.5.3.6. Design Data: The building program and any special studies, life cycle cost analysis that will affect the project design
- 2.5.3.7. Tower Line-of-Sight Studies (if required)
- 2.5.3.8. Service entrances, grease traps, trash locations, and recycling provisions
- 2.5.3.9. Design live loads
- 2.5.3.10. Sustainable Design Matrix

2.5.4. Schematic drawings and specifications for heating, ventilation, and air-conditioning (HVAC) will include:

- 2.5.4.1. Mechanical rooms, including dimensions, demonstrating accessibility of equipment for future maintenance activities.
- 2.5.4.2. Location of all chases required for air- conditioning systems
- 2.5.4.3. Location of all air handling and refrigeration equipment
- 2.5.4.4. Calculations indicating that the improvements can be accommodated by the existing supply system or equipment layout to provide the required additional capability
- 2.5.4.5. Narrative description of the proposed systems including a schematic diagram of air flow through the various system components (the general scheme outlined in the narrative must be previously discussed with the HAS Project Manager and agreed to at the Pre-design Conference). This narrative is to be part of the Project Report. The narrative will also address

the existing and proposed control systems and whether they are compatible, reprogramming of the existing system will be required, or whether replacement of the existing system is proposed. Any major changes to systems must be accompanied by a benefit cost and life-cycle cost analyses to support the proposed change.

2.5.5. Schematic drawings and specifications for Plumbing will include:

- 2.5.5.1. A brochure defining all plumbing fixtures
- 2.5.5.2. Narrative description of plumbing systems proposed, including source of exterior services
- 2.5.5.3. Location of janitorial closets, slop sinks, and supply storage

2.5.6. Schematic drawings and specifications for Electrical will include:

- 2.5.6.1. Electrical rooms
- 2.5.6.2. Narrative description of the proposed systems, including a schematic diagram of the distribution system (the general scheme outlined in the narrative must be previously discussed with the HAS Project Manager and agreed to at the Pre-design Conference)
- 2.5.6.3. Preliminary lighting layout showing general types of illumination to be used such as fluorescent, high intensity discharge (HID) lighting, or others
- 2.5.6.4. Tabulation of lighting levels to be used for the design of the lighting system
- 2.5.6.5. A sample lighting calculation for a typical room or area (exterior lighting projects)
- 2.5.6.6. An analysis indicating that satisfactory service is currently available, or identification of a need for additional service
- 2.5.6.7. Confirmation that the Designer understands that AC (BX) and MC cable will not be permitted on any project in HAS owned and operated facilities
- 2.5.6.8. Locations of permanent or temporary generators for emergency power (note:
- 2.5.6.9. if the policy decision is made to provide locations for temporary generators the layout plan will provide a basic location for permanent transfer switches to facilitate such connections.)
- 2.5.6.10. Location and protection required for maintaining existing service and
- 2.5.6.11. Identification of FAA cables and tenant owned utilities. The Designer will demonstrate understanding of the FAA systems and requirements for maintenance and replacement of FAA facilities

2.5.7. Schematic drawings and specifications for fire protection will include:

- 2.5.7.1. Fire vehicle access
- 2.5.7.2. Narrative description of fire protection systems proposed, including source of exterior fire protection services such as water mains
- 2.5.7.3. Schematic fire protection drawings with identification of all sprinkled areas and areas protected by other automatic suppression systems
- 2.5.7.4. Drawings will be drawn to a scale of 1/8 inches = 1 foot

2.5.8. Schematic drawings and Specifications for Communications will include:

- 2.5.8.1. Communication rooms
- 2.5.8.2. Confirmation that the Designer understands that no domestic water, sewer, or HVAC lines will be routed through or in the ceiling space above any communications room (main distribution frame [MDF] or intermediate distribution frame [IDF])
- 2.5.8.3. Confirmation that the Designer has read and understands the HAS IT Standards on the fly2houston web site to include MDF and IDF room size requirements.
- 2.5.8.4. Narrative description of the proposed systems including a schematic diagram of the communication system (the general scheme outlined in the narrative must be previously discussed with the HAS Project Manager and agreed to at the Pre-Design Conference)

2.5.8.5. Confirmation that additions or adjustments to the manned communication rooms will be made with ergonomically designed features to avoid muscular, skeletal, or sensory damage to the communications staff

2.5.9. Schematic drawings and specifications for Security will indicate:

2.5.9.1. Site security

2.5.9.2. Closed circuit television (CCTV)/monitor and equipment rooms

2.5.9.3. Narrative description of the proposed systems including a schematic diagram of the security system. The general scheme outlined in the narrative must be previously discussed with the HAS Project Manager and agreed to at the Pre-design Conference. The narrative will describe the compatibility of the proposed system with existing systems and what actions will be taken to ensure that all systems will work together at the completion of the project. If major changes are proposed in the existing system, the submission will include benefit- cost and life-cycle cost analyses in support of the proposal.

2.5.9.4. Confirmation that additions or adjustments to the manned CCTV monitor and equipment rooms will be made with ergonomically designed features to avoid muscular, skeletal, or sensory damage to the security staff.

2.5.10. Number of Submittals: Submit the number of sets of schematic drawings required by the Designer's contract to the HAS Project Manager for review and approval before proceeding to Design Development Stage.

2.6. Design Development Stage

2.6.1. Design Development Stage (mid-review): For all HAS Projects, the Design Development (60%) drawings and specifications will include all information in previous submittals plus all annotated comments from previous submittals and will indicate:

2.6.1.1. Proposed landscaping, exterior signing, exterior lighting, fencing and gates, or other site elements

2.6.1.2. Preliminary horizontal and vertical alignments for all roadways, drainage systems, and applicable exterior utilities tied into Airport coordinated system

2.6.1.3. Preliminary paving, parking layouts with horizontal and vertical ties to site survey and representative cross-sections

2.6.1.4. Preliminary cost estimates and construction schedule

2.6.1.5. Perspective Rendering required if the project has visual impact on the Airport development as a whole

2.6.1.6. Design data and analysis

2.6.1.7. Soil tests data and analysis

2.6.1.8. Sustainable Design Matrix

2.6.1.9. Outline specifications

2.6.1.10. Project report that includes a discussion of each significant design decision and its rationale

2.6.1.11. Quantity or schedule of value outline indicating the assets that are included in the project and will be tracked throughout. Agreement on the assets included will be between HAS and HAS Finance and will be established by meeting with the Designer approximately one month prior to the 60 percent submittal date.

2.6.2. Design development drawings and specifications for Airfield Projects will include:

- 2.6.2.1. Horizontal and vertical layouts for all proposed airfield paving, emergency roads, haul routes, laydown sites, and drainage features
 - 2.6.2.2. Layouts for proposed airfield electrical circuits, NAVAIDS, and underground utilities
 - 2.6.2.3. Drainage calculations and preliminary hydraulic gradient profiles supporting the utility layout and potential underground conflicts with both existing and proposed utilities
 - 2.6.2.4. Typical sections for each type of paving, including surface and groundwater drainage features.
 - 2.6.2.5. Site access points, lay-down areas, and haul routes with preliminary protection details to support the National Pollutant Discharge Elimination System (NPDES) permit application
 - 2.6.2.6. Typical details for all paving, jointing, sealing, drainage, electrical, utilities, etc
 - 2.6.2.7. Preliminary safety plan, phasing plan, and draft FAA Notification of Construction Form 7460-1
 - 2.6.2.8. A listing of any previously unreported proprietary specification or specifications written around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. Exceptions include products that are on a pre-approved list published by the FAA or a list of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS Engineer and/or the FAA, as required, can be obtained
 - 2.6.2.9. **Passenger Loading Bridges** (PLB)/ Passenger Boarding Bridges (PBB): PLB/PBB must show operational equipment specifications for model type, tunnels, swing, lift, retraction and extension limits, and proposed aircraft fits
 - 2.6.2.10. Indicate fuel pits, 400 hertz, and pre- conditioned air (PCA) equipment with proposed aircraft fits
 - 2.6.2.11. Indicate lines of all taxiway, lead-in and parking positions of proposed aircraft and movements onto active areas of the AOA
- 2.6.3.** Design development drawings and specifications for Buildings will include, but not be limited to:
- Floor plans
 - Framing plans
 - Ceiling plans
 - Roof plans
 - Sections and elevations
 - Details of typical conditions
- 2.6.4.** Design development drawings and specifications for HVAC will include the elements described below:
- 2.6.4.1. Mechanical rooms will be drawn to scale showing all equipment and required connecting ductwork. This requirement is mandatory to establish the space needs for mechanical equipment.
 - 2.6.4.2. Routing of major piping systems when space is a consideration. Ductwork for remainder of project in one line form to indicate the breakdown of proposed zones.
 - 2.6.4.3. Include a report on design criteria and system loads in the Project Report.
 - 2.6.4.4. Specifications will be in the form of an outline covering all HVAC equipment and materials to be used in the project.
 - 2.6.4.5. A listing of any previously unreported proprietary specification, or specifications written

around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. Exceptions include products that are on a pre-approved listing published by the FAA or a listing of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS Engineer and/or the FAA, as required, can be obtained.

2.6.5. Design development drawings and specifications for Plumbing will indicate:

- 2.6.5.1. All plumbing fixtures including those for disabled persons drawn to scale.
- 2.6.5.2. Roof drains and route of storm drains to storm sewer.
- 2.6.5.3. Sump pump and sewage ejector locations.
- 2.6.5.4. One typical riser diagram for each type of system.
- 2.6.5.5. Report on design criteria and system loads, include in Project Report.
- 2.6.5.6. Specifications will be in the form of an outline covering all plumbing equipment and materials to be used in the project.
- 2.6.5.7. A listing of any previously unreported proprietary specification, or specifications written around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. Exceptions include products that are on a pre-approved listing published by the FAA or a listing of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS Engineer and/or the FAA, as required, can be obtained.

2.6.6. Design development drawings and specifications for Electrical will include:

- 2.6.6.1. Electrical rooms with all equipment drawn to scale, as well as door opening and space utilization beyond the doors, to determine the viability of pulling the machinery out for replacement when necessary. This requirement is mandatory to establish the space needs for electrical equipment.
- 2.6.6.2. Routing of feeder and service conduit systems when space is a consideration.
- 2.6.6.3. A one-line diagram of distribution system will indicate approximate equipment and service size.
- 2.6.6.4. Lighting layout for projects, including exterior systems, with tabulated loads.
- 2.6.6.5. A brochure showing cut sheets on all lighting fixtures, and poles, proposed for project. Submit five sets of design development electrical systems plans for review and approval before proceeding to final working drawings or Contract Bid Documents.
- 2.6.6.6. A calculation indicating that existing service is adequate, or identifying additional service needs, as well as estimates to provide additional service required in the Project Report.
- 2.6.6.7. Description of the accommodation of emergency power requirements, including a detailed description of the items that will be connected to the emergency buss (include in Project Report). Note that this may require a policy decision on the part of HAS and needs to be identified early in the design process
- 2.6.6.8. Specifications will be in the form of an outline covering all electrical equipment and materials to be used in the project.
- 2.6.6.9. A listing of any previously unreported proprietary specification, or specifications written around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. The exception is for products that are on a pre-approved listing published by the FAA or a listing of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS

Engineer and/or the FAA, as required, can be obtained.

2.6.7. Design development drawings and specifications for Fire Protection will include:

- 2.6.7.1. Fire protection plans will indicate all underground water mains and their sizes.
- 2.6.7.2. Fire hydrant locations.
- 2.6.7.3. Proposed water supply connections to sprinkler systems.
- 2.6.7.4. Control valve locations.
- 2.6.7.5. Fire alarm panel locations.
- 2.6.7.6. Smoke control/removal systems layout.
- 2.6.7.7. Underground valve meter pit.
- 2.6.7.8. Standpipe locations.
- 2.6.7.9. Include a description of the design rationale for the system in the Project Report.
- 2.6.7.10. Specifications will be in the form of an outline covering all fire protection items, equipment, and materials including manufacturers and model numbers to be used in the project (this will include smoke/heat detectors and pressure, flow, and tamper switches). Note that the current standard system used by HAS is Notifier and all new installations or renovations must use equipment manufactured by Notifier. Only Notifier certified technicians will be permitted work on or install the equipment.

2.6.8. Design development drawings and specifications for Communications will include: Communication rooms with all equipment drawn to scale. This requirement is mandatory to establish the space needs for equipment.

- 2.6.8.1. One-line diagram of communication system will indicate intercom, speakers, equipment, terminal boards, and cabinets.
- 2.6.8.2. Include a description of the design rationale for the system in the Project Report.
- 2.6.8.3. Specifications will be in the form of an outline covering all communication equipment and materials to be used in the project.
- 2.6.8.4. A listing of any previously unreported proprietary specification, or specifications written around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. The exception is for products that are on a pre-approved listing published by the FAA or a listing of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS Engineer and/or the FAA, as required, can be obtained.

2.6.9. Design development drawings and specifications for Security will indicate:

- 2.6.9.1. CCTV/monitor and equipment rooms with all equipment drawn to scale. Provide adequate working clearance for monitors and operator console. This requirement is mandatory and is required to establish the space needs for equipment.
- 2.6.9.2. One-line diagram of security system will indicate control panels, sensors, cameras, monitors, telephone interface, and any other system devices critical to operation.
- 2.6.9.3. Include a description of the design rationale for the system in the Project Report.
- 2.6.9.4. Specifications will be in the form of an outline covering all security equipment and materials to be used in the project.
- 2.6.9.5. A listing of any previously unreported proprietary specification, or specifications written around a single manufacturer's product, or any specification naming manufacturer or manufacturers of acceptable products along with a justification for the non-competitive selection. The exception is for products that are on a pre-approved listing published by the

FAA or a listing of pre-purchased materials or products that were competitively selected by HAS with guaranteed prices for the project. This is done so that prior approval of the HAS Engineer and/or the FAA, as required, can be obtained.

2.6.10. Number of Submittals: Submit the number of sets of design development plans required by the Designer's contract, to the HAS Project Manager for review and approval before proceeding to construction documents stage.

2.7. Construction Document Stage

2.7.1. Construction Document Stage: The Construction Documents (95 % and 100%) drawings and specifications will include all information in previous submittals plus all annotated comments from previous submittals and will include (at a minimum):

- 2.7.1.1. Complete drawings with all plan, profile, detail, section, schedule, calculation, and miscellaneous sheets included
- 2.7.1.2. Specifications complete in final typed form
- 2.7.1.3. Final construction schedule
- 2.7.1.4. Final cost estimate
- 2.7.1.5. Storm Water Pollution Prevention Plan (SWPPP)

2.7.2. Construction document drawings and specifications for airfield projects will include:

- 2.7.2.1. All proposed paving and facilities
- 2.7.2.2. Proposed grading and surface contours
- 2.7.2.3. Final profiles and flow lines for all drainage systems
- 2.7.2.4. All required sections and details
- 2.7.2.5. For federally funded projects, include a limited (abbreviated) Project Report meeting the FAA's requirements for an Engineering Report
- 2.7.2.6. Estimated quantities including paving percent within limits (PWL) bonus
- 2.7.2.7. Verification of compliance with all applicable codes and/or regulatory documentation of compliance with all agencies with jurisdiction over the Project

2.7.3. Architectural construction document drawings and specifications will include:

- 2.7.3.1. Index, symbols, abbreviations, key plans and general notes
- 2.7.3.2. Demolition, site plan, and temp work
- 2.7.3.3. Plans, material schedule, door schedule, and key drawing
- 2.7.3.4. Sections and exterior elevations
- 2.7.3.5. Detailed floor plans
- 2.7.3.6. Interior elevations
- 2.7.3.7. Reflected ceiling plans
- 2.7.3.8. Vertical circulation, stairs, elevators, and escalators
- 2.7.3.9. Exterior details
- 2.7.3.10. Interior details
- 2.7.3.11. All information from previous submittals plus annotated comments from last submission review

- 2.7.3.12. For any construction that will require existing floors or walls to be penetrated, typically by coring, include requirement that facility be x-rayed to prevent damage to existing structure and equipment.
- 2.7.3.13. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released
- 2.7.4.** Structural construction document drawings and specifications will include:
 - 2.7.4.1. Index, symbols, abbreviations, key plan, notes, and loading criteria
 - 2.7.4.2. Demolition site work
 - 2.7.4.3. Foundation plans and details, foundation design criteria
 - 2.7.4.4. Framing plans and details
 - 2.7.4.5. Elevations
 - 2.7.4.6. Details
 - 2.7.4.7. Schedules
 - 2.7.4.8. Special design
 - 2.7.4.9. All information in previous submittals plus annotated comments from last submission review
- 2.7.5.** Construction document drawings and specifications for HVAC will include:
 - 2.7.5.1. All air-conditioning systems and all ductwork in two lines with all fittings drawn to scale
 - 2.7.5.2. Sections through mechanical rooms to adequately describe the construction requirements
 - 2.7.5.3. Schedule of all major items of equipment drawn on the plan sheets to indicate performance characteristics
 - 2.7.5.4. All piping systems complete with necessary sections to clarify routing
 - 2.7.5.5. Applicable details, including those included in the design criteria modified to suit the project
 - 2.7.5.6. Flow diagrams and riser diagrams in isometric form for each piping and ventilation system except drains
 - 2.7.5.7. The HVAC load, ventilation and air pressurization calculations for future reference, clearly indicating all zoning requirements. Calculations will clearly indicate all zoning requirements, etc.
 - 2.7.5.8. Evidence that the type and contents of the Test and Balance Reports to be furnished will coincide with the work scope of the system being designed.
 - 2.7.5.9. All information in previous submittals plus annotated comments from last submission review
 - 2.7.5.10. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released
 - 2.7.5.11. Evidence that a constructability check for continuity and conflicts among all building systems was performed
- 2.7.6.** Construction document drawings and specifications for Plumbing will indicate:
 - 2.7.6.1. All plumbing fixtures shown and identified by a number
 - 2.7.6.2. Riser diagrams in isometric form for all plumbing risers in the building
 - 2.7.6.3. Flow diagrams for all pressure systems including hot and cold water, gas, oxygen, air vacuum, etc.
 - 2.7.6.4. Details such as lavatory connection pump, hot water generator, water softener, sewer manholes, backflow prevention, water header, etc.

- 2.7.6.5. A schedule on drawings with all major equipment.
- 2.7.6.6. Detailed description of plumbing fixtures, which may also be scheduled.
- 2.7.6.7. All information in previous submittals plus annotated comments from last submission review.
- 2.7.6.8. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.

2.7.7. Construction document drawings and specifications for Electrical will include:

- 2.7.7.1. All electrical systems drawn to scale including light fixtures, distribution equipment, and other miscellaneous system components.
- 2.7.7.2. Schedule of all light fixtures, switchboards, and motor control centers.
- 2.7.7.3. Schedule of all panel boards, to be door- in-door type, including connected loads and demand loads.
- 2.7.7.4. One-line diagram of electrical distribution system including all equipment, feeder, service ratings, and available symmetrical three phase fault current at each device.
- 2.7.7.5. Applicable standard details from these guidelines modified to suit project.
- 2.7.7.6. One-line diagrams for each system including the emergency buss and any permanent generator or transfer switch locations.
- 2.7.7.7. All information in previous submittals plus annotated comments from last submission review.
- 2.7.7.8. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.

2.7.8. Construction document drawings and specifications for Fire Protection will include:

- 2.7.8.1. All fire risers shown and identified by a number.
- 2.7.8.2. Flow diagrams and riser diagrams for fire protection pressure systems.
- 2.7.8.3. Details such as fire hose cabinets, fire hydrants, fire pumps, fire department connections, backflow prevention, water header, connections, cathodic protection, and riser insulation's, etc.
- 2.7.8.4. All major equipment scheduled on drawings, including fire sprinkler drawings indicating all piping, sizes and locations, drawn to scale of no less than percentage inch equals one foot.
- 2.7.8.5. All information in previous submittals plus annotated comments from last submission review.
- 2.7.8.6. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.

2.7.9. Construction document drawings and specifications for Communications will include:

- 2.7.9.1. All communication system equipment, cabinets, boards drawn to scale, telephone outlets, intercom stations, repeater stations, etc.; one-line diagram of communication systems.
- 2.7.9.2. Applicable standard details from these guidelines modified to suit project.
- 2.7.9.3. All information in previous submittals plus annotated comments from last submission review.
- 2.7.9.4. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.

2.7.10. Construction document drawings and specifications for Security will indicate:

- 2.7.10.1. All security system control and monitoring equipment drawn to scale, sensor locations, and types.
 - 2.7.10.2. Applicable standard details from these guidelines modified to suit project.
 - 2.7.10.3. Security devices.
 - 2.7.10.4. Security signage.
 - 2.7.10.5. Individual zone location and designation, with all alarm device locations, including the security alarm and data panel, annunciators, and any other devices necessary for the operation of the system.
 - 2.7.10.6. All information in previous submittals plus annotated comments from last submission review.
 - 2.7.10.7. A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.
- 2.7.11. Number of Submittals:** Submit the number of sets of Contract Bid Documents required by the Designer's contract for review and approval before printing for distribution to bidders. The documents at this point must be ready to sign and be sealed pending approval by the HAS Project Manager. Once these documents are approved, signed and sealed, they can be provided to contractors for bidding purposes.

2.8. Specification Format

- 2.8.1. For all airfield construction and other AIP funded projects, contract documents will be prepared in accordance with AC 150/5370-10, or the latest edition. Section 1, including Notice to Bidders, Instructions to Bidders, Proposal Forms, Bid Schedule Forms, Bond Forms, General, and Special Provisions of the contract documents will be prepared based on guidance and direction from the HAS Project Manager and must comply with City of Houston (COH) standard requirements.
- 2.8.2. For all non-Airport Improvement Program (AIP) projects, or the components of projects that are not covered by FAA, specifications will be in accordance with the Construction Specification Institute (CSI), MasterFormat™ latest COH approved edition, or as approved by the HAS Project Manager.

2.10. Coordination of Design

- 2.10.1. The prime design firm is responsible for and will ensure that the design is coordinated between disciplines. The project (facility) will be fully coordinated across all disciplines with required access for any mechanical, electrical, and plumbing (MEP) or other additional systems which require maintenance or inspections.
 - 2.10.1.1. **HVAC:** The final HVAC drawings will, as a minimum, be checked for the following:
 - Electrical lighting fixtures will be checked for conflict with air devices, sprinkler heads, ceiling mounted speakers, and other ceiling mounted devices.
 - Duct work will be checked for clearance between ceiling construction and underside of beams, recessed lighting fixtures and other interferences where space is limited.
 - Large mechanical system piping will be coordinated with building structure to assure clearances and accessibility for maintenance. Piping and electrical switchgear locations are

to be coordinated.

- Coordinate requirements for louvers, equipment supports and other devices serving mechanical systems, but furnished under the general construction section of the project.
- Coordinate correct rough-in requirements for all equipment.
- Drawings and specifications will be checked for conflict
- Drawings will be coordinated for size and location of all chases or dedicated corridors (i.e. space dedicated for future baggage handling system).

2.10.1.2. Plumbing: The final Plumbing drawings will, as a minimum, be checked for the following:

- Piping will be coordinated with building construction, beams, etc., to assure clearances and accessibility for maintenance. Piping and electrical switchgear locations are to be coordinated.
- Piping will be checked for clearance between ceiling construction and underside of beams, recessed lighting
- fixtures and other interferences where space is limited.
- Piping, ductwork, electrical conduits, etc. will be checked for interferences that would prevent proper installation of each system.
- Coordinate correct rough-in requirements for all equipment.
- Drawings will be coordinated for size and location of all chases.

2.10.1.3. Electrical: The final Electrical drawings will, as a minimum, be checked for the following:

- Electrical lighting fixtures will be checked for conflict with air devices, sprinkler heads, and ceiling-mounted devices.
- Large electrical system conduit and pull boxes will be coordinated with building construction, beams, etc., to assure clearances and accessibility. Piping and electrical switchgear locations are to be coordinated.
- Drawings and specifications will be checked for conflicts.
- Drawings will be coordinated for size and locations of all chases.

2.10.1.4. Fire Protection: The final Fire Protection drawings will, as a minimum, be checked for the following:

- Piping will be coordinated with building construction, beams, etc., to assure clearances and accessibility for maintenance. Piping and electrical switchgear locations are to be coordinated.
- Routing of sprinkler piping will have minimum turns to avoid building construction, etc.
- No areas are to be designed without fire protection/detection.

2.10.1.5. Communication: The final Communication drawings will, as a minimum, be checked for the following:

- Ceiling type speakers will be checked for conflict with light fixtures, air devices, sprinkler heads, etc.
- Large communication system conduit and pull boxes will be coordinated with building construction, beams, et., to assure clearances and accessibility.

2.10.1.6. Security: The final Security drawings will, as a minimum, be checked for the following:

- Security system components and types and locations will be coordinated through the HAS Project Manager to properly interface with the existing system, as applicable to a project.
- Coordinate design to allow for uninterrupted operation of existing security systems. Security must be maintained during construction.
- Large security system conduit and pull boxes will be coordinated with building construction, beams, etc., to assure clearances and accessibility.

2.10.1.7. Exterior Utilities: The final Exterior Utility drawings will, as a minimum, be checked for the following:

- Electrical lighting poles, manholes, handholds and underground conduit will be coordinated with existing utility locations as well as installation of other new utilities.
- Drawings and specifications will be checked for conflicts.

2.9.1.7. Sustainability: The final drawing set will be checked against the referenced inclusion of supporting design per the Sustainable Design Matrix. This is provided as part of the Project Report.

2.10. Construction Phasing Documentation

2.10.1. Phasing Plans: The building construction phasing drawings will, at a minimum, be checked for the following:

- 2.10.1.1.** Contractor movement is not adversely affected by pedestrian corridors. Contractor laydown area is not separated from the worksite by maintenance of traffic accommodations.
- 2.10.1.2.** Safe fire exit routes are maintained through construction and exits on the AOA is minimized (means of egress).
- 2.10.1.3.** Construction is adequately screened from the public in maintained areas.
- 2.10.1.4.** Construction shelters that will be in place for long stages are visually and acoustically designed to minimize interface and maintain security.
- 2.10.1.5.** Seemingly innocent notations that can adversely affect the budget or schedule are thoroughly vetted and venues examined so that the schedule and budget are adequately compensated. For an example, a temporary fire corridor that requires several small adjustments through the Construction Phase, but every adjustment requires substantial work to maintain the fire protection level.
- 2.10.1.6.** A listing of any item that has been included in an established allowance and how the allowance will be allotted and released.

2.11. Commissioning Procedures

2.11.1. Commissioning is required on all HAS construction projects, including development, maintenance and renovation projects that require the construction of two or more major building systems (e.g. structural, electrical, plumbing, or HVAC). For HAS construction projects subject to the commissioning requirement, the City Engineer or designee will not issue a Notice to Proceed until HAS approves the Commissioning Plan. The City Engineer or designee will not issue a notice of substantial completion until all pre-occupancy commissioning activities identified in the Commissioning Plan have been successfully completed and appropriately

documented.

2.12. Bidding

2.12.1. The following describes the general project procurement processes for a design-bid- build procurement process:

- 2.12.1.1. **Project Solicitation:** Proposals will be solicited in accordance with the COH procedures and regulations. HAS will coordinate and be responsible for the contracting arrangements. Public advertisement for bids by HAS will be run for two consecutive Fridays in the Houston Chronicle. Bid announcements will also be posted on the HAS website.
- 2.12.1.2. **Sale and Issuance of Contract Documents to Contractors:** Beginning on Monday after the first Friday advertisement, bid packages will be available to bidders from source indicated in the advertisement. The Designer must confirm this procedure with the HAS Project Manager
- 2.12.1.3. **Pre-Bid Conference:** HAS will conduct a Pre-Bid conference for the prospective bidders. The Designer will brief the bidders on the overall scope of the project, assist HAS in answering questions from bidders and help conduct a site tour.
- 2.12.1.4. **Addenda:** If questions come up during the Pre-Bid Conference or if there are clarifications required, the Designer will provide answers to the HAS Project Manager. HAS is responsible for issuing all Addenda.
- 2.12.1.5. **Bid Opening:** Bid opening will be conducted in accordance with the current COH procedures. After the bid opening, the Designer will perform a bid analysis. Upon completion of the bid analysis a recommendation to award the contract to the lowest responsible bidder will be issued to HAS for approval.
- 2.12.1.6. **Pre-Construction:** Upon approval of the project, the applicant, Designer, and Contractor will meet with HAS Representatives for a pre- construction conference. At such time, principal aspects of coordination will be established: project schedule, coordination, inspections, as well as any other items of a timely nature to the project.

Part 3 - Permitting and Construction

3.1. Permitting

- 3.1.1. HAS and the COH Houston Public Works (HPW) Department work collectively to process permits and plan reviews. The two groups will review and approve building permits and complete code enforcement-related inspections for all City and Airport-required permits for all projects on HAS premises, including tenant improvement projects, concessions and CIP/ACIP. This HAS internal permitting team, the Building Standards Group (BSG), may also provide technical third-party design reviews at the end of each design stage for familiarity with each project's scope. BSG will also review and approve construction documents issued for construction permit. BSG will also perform building and site inspections on behalf of the City. HPW will maintain oversight of certain disciplines like floodplain management, fire control systems (through the City Fire Marshall), and any improvements to any City-owned public utility, including but not limited to water lines, sanitary lines, sanitary lift stations, etc.

- 3.1.2. Construction Permit Required:** A Construction Permit must be obtained from the BSG to construct, enlarge, alter, repair, move, demolish, or change the occupancy of a building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical (HVAC) or plumbing and fire protection system, or to perform any construction work on Airport property or jurisdiction.
- 3.1.3. Submittals:** The Contractor will pay the building permit fee and submit the documents listed in the Tenant Improvement Program Process after award of the contract and before the construction permit has been issued. A Construction Permit will not be issued until a confirmation of permit fee payment is received from HPW. Additional information regarding the Construction Permit submittal procedures can be found on the HAS website.
- 3.1.3.1.** The construction documents will be submitted in electronic format (pdf) for plan review. The Designer will submit the construction document application for permit at 95 percent completion. Please note that for HAS projects, each sheet will be signed by an appropriately licensed HAS official like the Assistant Director or the City Engineer. Also, when applying for a construction permit, the COH requires a survey for asbestos containing materials (ACM) by someone licensed by the Texas Department of State Health Services (DSHS). If asbestos materials are present, then specifications for abatement must be prepared by a licensed Environmental Consultant.
- 3.1.3.2.** Drawings and specifications will be prepared by an architect; engineer or other design professional licensed in the State of Texas to practice as such and, except as allowed by the professional licensing authority or authority having jurisdiction, will bear the seal of the design professional responsible for preparation of the drawings and specifications. Licensed professional means an individual who is licensed in the appropriate discipline for the drawings and who is responsible for and in charge of their preparation. All submittals shall bear the interim review seal of the licensed professional in responsible charge of the design, and shall follow all state rules, including date of issue. Submittals shall also clearly show the plan issue or revision title, such and "Issue for Permit" or "95% Submittal". Refer to CAD Standards for more information.
- 3.1.3.3.** The Designer shall complete all accessibility requirements for all projects. The Designer must register the project, obtain and submit to HAS the Texas Department of Licensing and Regulation (TDLR) assigned EABPRJ# (TDLRs acronym identifying a project number assigned by that agency) with the permit application. In addition, the BSG requires completion of the Proof of Submittal form at the time of TDLR application. This form is available on the BSG website. A copy of the plan review notes from the Registered Accessibility Specialist (RAS) is also required prior to issuance of the permit. A construction permit cannot be issued until all required information has been received and approved.
- 3.1.3.4.** If applicable to the Project, the Designer shall complete the Airspace Study Application form FAA 7460-1, and work with the HAS Project Manager to coordinate approval through the FAA. Approval from the FAA is required for, among other things, projects that affect a change to the Airport Layout Plan or for the use of cranes and certain other construction equipment. Permits for construction will be limited until required FAA approvals are obtained.
- 3.1.4.** The Contractor will provide a check payable to the COH, or by credit card, for payment of Plan Review and Permit Fees. Payment must be made at the Building Official's office (Houston Permitting Center, 1002 Washington Avenue, Houston, Texas 77002, 713-535-7510 or at any COH substation location). Alternatively, payment may be made online or from an existing contractor payment account. For HAS Projects, a certification letter, internal memorandum or email that states the estimated cost of construction must be provided to the Building Official. This sum must be consistent with the amount indicated on the required TDLR Project Registration form described above. Payment may also be made online.
- 3.1.5. Fire Protection System Permitting:** Prior to proceeding with the installation of fire suppression

or fire alarm systems, submit shop drawings, hydraulic calculations, and related submittal data in electronic pdf format to the Building Official. The COH Fire Marshal's department will issue permits for fire protection systems.

- 3.1.6. Construction Permit Issued:** The Building official will approve the construction application and issue a construction permit once it has been determined that the project construction documents comply with the applicable construction codes and standards and that all other requirements have been met.
- 3.1.7. Environmental Close-Out:** Unless agreed otherwise, the Designer will complete an Environmental Assessment Memorandum outlining the environmental conditions of the project and provide an Environmental Close-Out Checklist that will be completed and submitted to the HAS Project Manager and HAS Environmental for review and record at the close of construction.
- 3.1.7.1.** Applicant is required to schedule a meeting with HAS to discuss the project scope, typically at the 15 percent stage in a project's development. Based upon the scope, HAS will provide the technical input for completing the Environmental Compliance Checklist (ECC). The purpose of this checklist is to identify the environmental regulations that apply to the proposed construction or to the operation of the completed work, structure, or facility. The applicant must submit the Checklist and all applicable attachments to the HAS Project Manager prior to applying to the permit.

3.2. Construction

- 3.2.1. HAS Insurance Requirements:** A current insurance certificate is required for every Contractor performing work on the premises of the Airport and/or on any COH Project. The minimum coverage requires is Comprehensive General Liability, Workers Compensation and Automobile and Truck Liability at such limits as defined the Designer's or Contractor's contract with the City of Houston. For work in the AOA, an additional Umbrella or Excess Liability is required. Coverage levels are as stated in individual contracts. Consult with the HAS Project Manager for specific Insurance requirements.
- 3.2.2. Project Construction and Inspection:** Through the Notice to Proceed letter, the applicant is given instructions to contact the HAS Project Manager for the purpose of scheduling a pre-construction conference. The conference must include the applicant, the applicant's contractor and the Contractor's major Subcontractors. The Contractor will be briefed on rules, regulations and procedures to be followed for construction projects at HAS. The Contractor must submit an emergency phone list, any required submittals and a construction schedule. After posting the Construction Permit and placing approved construction documents at the project site, and receiving a Notice to Proceed, the Contractor may begin construction.

An inspection is required before covering or concealing any electrical, plumbing, utility, mechanical, fire sprinkler, fire alarm or structural systems. Work may not progress beyond any point for which an inspection is required until the Contractor receives an approved inspection report for the inspected work. Further, the location of all new or replaced electrical, mechanical, plumbing, utility, fire sprinkler, fire alarm, communications, data, or structural systems will be either confirmed to be in the location shown on the plans or its altered location identified on the contractor's set of red-line drawings that form the basis of the record drawings.

The HAS Project Manager or HAS Inspector may request that an HAS survey crew verify the locations on a random basis for use as a quality control measure in evaluating the Contractor's red-line plan set. Refer to the contractor agreement documents and Division 01 contract specifications for additional requirements.

- 3.2.3. Site Clean-Up:** The Designer must specify that the Contractor will be responsible for maintaining an orderly and accommodative environment of the construction area, lay- down

areas, parking areas, areas used for debris disposal, and any area used by the Contractor for any purpose and will, prior to conclusion of the work, remove all rubble, debris, and surplus material occasioned from the immediate site. In addition, the Contractor will similarly render and restore all off-site areas disturbed during the construction of the facility. Each project will contain such signage alerting the public to the temporary nature of the visual or operational impacts of the project and advising when the work will be completed as required by HAS.

3.2.4. Operational Procedures: All HAS Airports are in operation 24 hours a day and construction procedures must provide safe operation during the entire period. In order to provide operating safely, a system of tags will be provided by HAS and will be specified in the construction documents for turning central chilled water systems, central hot water systems, steam, plumbing or utility systems on and off to facilitate construction. The Designer will identify all interface valves on the plans or provide for new valves to use for sectionalizing. Prior to sectionalizing or turning off systems, the Contractor will tag the valve and his representative will sign. At the same time, the HAS Project Manager and the respective operating and maintenance organizations will all sign at the same time. Prior to turning the system back on, all representatives will again sign off on the operation.

3.2.5. Operational Safety: In order to provide operational safety, the Contractor is to notify the appropriate Airport Operations Center (AOC) 48-hours prior to any proposed activity that will shut down or otherwise affect the operation of any utility, system or operation so that a work area notice (WAN) can be issued. Also, notification must be made to the AOC two hours prior to commencement of work and prior to turning fire protection/detection systems, or any other system, on or off. The Contractor is expected to give the following information when submitting the 48-hour notice and again once in contact with the Operations Center:

- Name and phone number of the Contractor
- System identification (i.e. sprinkler valve number, fire alarm zoning identification)
- Time the system will be deactivated
- Time the system will be reactivated
- Total time the system will be out of service
- The areas, activities, or zones that will be affected

3.2.6. Testing: Prior to the time the system is connected in the main system, detailed testing requirements will be completed as specified by the Designer. Refer to Division 1 Specifications for specific COH testing requirements.

3.3. Record Documents

3.3.1. Record documents: as-constructed, reflecting the final installation after all modification and changes will be furnished to the HAS Project Manager at the end of each construction project. Record specifications will be those used for the actual construction, marked with changes made by addendum, change order, or product substitution.

3.3.2. Design Submittal File Formats: Designer will submit drawings electronically at each deliverable design stage milestone in the following formats:

3.3.2.1. All files and documents used to create design submittals will be submitted in both native authoring format, PDF format and any prescribed deliverable format.

3.3.2.2. All Models and CAD files will be delivered in the airport-specific NAD83 State Plane Coordinate System as defined in the HAS CAD/Geospatial Data Standards and Procedures.

3.3.2.3. All electronic deliverables will include a description of content, required links, references, etc. required for use.

3.3.3. Building Information Modeling (BIM) model and design drawings will be delivered in the following formats:

3.3.3.1. Autodesk Revit Model(s) used to generate documentation with approved HAS version

3.3.3.2. Autodesk Civil3D native Model(s) used to generate documentation with approved HAS version

3.3.3.3. **An Autodesk Navisworks:** NWC containing each model's specific scope with approved HAS version

3.3.3.4. Autodesk AutoCAD 2D files for each sheet compliant with HAS BIM standards

3.3.3.5. PDF of each drawing

3.3.4. Refer also to the HAS BIM Standards for further information.

3.4. Certificates of Occupancy / Certificate of Compliance / Use

3.4.1. The Contractor must deliver to the HAS Project Manager the completed Environmental Close-Out Checklist and Sustainable Design Matrix and proof of final inspection and compliance with the Texas Accessibility Standards (TAS) at the close of construction. Upon acceptance of the Environmental Close-Out Checklist, Sustainable Design Matrix and of compliance with the Texas Accessibility Standards (TAS) by the HAS Project Manager, other required submittals and acceptance of the work following all required final inspections, the Building Official will issue a Certificate of Occupancy / Certificate of Compliance / Use. After receipt of the required Record Documents and correction or completion of any outstanding items of work, the HAS Project Manager will issue the Notice of Final Completion.

04 - SAFETY



04 – Safety

1.1. Design for Safety

- 1.1.1.** The safety and wellbeing of Houston Airport System (HAS) employees, contractors customers, and tenants will be designed into every aspect of every project.
- 1.1.2.** HAS Safety and Emergency Management Division or their designee will be contacted/ consulted during the design phase of all projects to ensure adequate attention has been given design for safety considerations.
- 1.1.3.** General principles will be employed by Architects and Engineers (Designers) that conform to the following criteria:
- Designers will prepare a design plan that eliminates, as far as reasonably practicable, all foreseeable design risks for demolition, construction, operation and maintenance.
 - Where not reasonably practicable to eliminate foreseeable design risks, architects/designers will propose modification(s) to the design plan that would reduce design risks to as low as reasonably practicable.
 - When reducing risks, design risks will be reduced at its source and collective protective measures will be used instead of individual protective ones.
 - Designers will provide information relevant to the design, construction or maintenance of the structure to the HAS, stakeholders or their designees as required.
 - Designers will attend, participate and potentially lead when requested, Design for Safety Review Meetings when required by HAS, stakeholders or their designees.
 - Designers will ensure that any design sub consultant of any contractual tier is competent to perform their duties under all applicable laws, codes and/or standards.
 - Designers will ensure that design sub consultants of any contractual tier are provided with all relevant information in performance of their portion of the overall design obligation.
 - Designers are responsible for their duties even if a design sub consultant of any contractual tier is employed.
 - Designers will ensure all designs are coordinated, across all disciplines, and checked to so that one individual sub consultant's design does not lead to creation of a safety risk during demolition, construction, operation and maintenance.
 - Designers will ensure that all designs are fit for purpose as it relates to demolition, construction, operation and maintenance ultimately with the
 - safety and health of stakeholders, project participants, the general public and end users being the main objective.
 - Designers will ensure that all designs are compliant to all statutory local, state and federal standards.

1.2. Life Safety

1.2.1. Automatic External Defibrillators (AEDs):

Follow City of Houston (COH) Policy AP2-19, for administrative requirements. Proposed locations require COH Medical Director approval.

1.2.2. Emergency eyewash stations and showers must meet 29 Code of Federal Regulation (CFR) 1910.151(c) and American National Standard Institute (ANSI) Z358.1, may also be required at the discretion of HAS.

1.2.3. Fire extinguishers must comply with National Fire Protection Association (NFPA) and Occupational Safety and Health Administration (OSHA).

- 1.2.4.** Crosswalks must be designed to be properly identified, marked and lighted for pedestrians to use at passenger pick-up and drop-off area.
- 1.2.5. Emergency Compliance:**
- All emergency items will comply with the American with Disabilities Act (ADA) and Texas Department of Licensing and Regulation (TDLR) standards and regulations.
 - Design and incorporate technology to immediately display emergency messages on all public computer/display monitors (flight information display system [FIDS], gate displays, etc.) throughout passenger terminal facilities.
 - Design, incorporate, and identify severe weather shelters in both secure, beyond Transportation Security Administration (TSA) checkpoints and other public areas before TSA checkpoints.

05 - APPLICABLE CODES

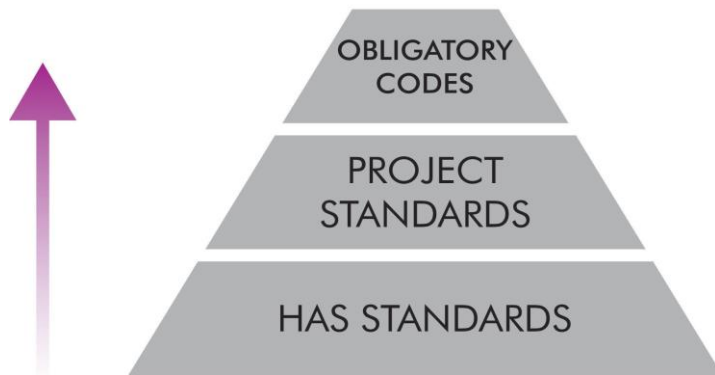


05 - Applicable Codes

1.1 Overview

- 1.1.1.** This section addresses minimum codes, guidelines, regulations and standards that must be appropriately applied on a project specific basis in designing facility systems and components for the Houston Airport System (HAS).
- 1.1.2.** The City of Houston (COH) regulates construction within the boundaries of George Bush Intercontinental Airport (IAH), William P. Hobby Airport (HOU), and Ellington Airport (EFD). These requirements are based on the adoption of, and amendments to, the International Building Code and all other codes as adopted by the City of Houston <https://www.houstonpermittingcenter.org/help/codes>
- 1.1.3. Manual for Design of Streets and Roadways:** Texas Department of Transportation (TxDOT) “Highway Design Section Operations and Procedures Manual,” latest version, will govern the design of streets and roadways that connect to or are otherwise governed by the standards of the State of Texas Department of Transportation.
- Construction specifications will be taken from “Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic,” latest edition, published by the COH Houston Public Works (HPW), except as modified herein.
- 1.1.4. Federal Aviation Administration (FAA) Standards:** These standards may be obtained from:
- FAA, Post Office Box 1689, Fort Worth, Texas 76101;
 - U.S. Department of Transportation, Subsequent Distribution Section, M-4943, Washington, D.C. 20590;
 - Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402;
 - Or other FAA regional offices.
- Most FAA standards and forms are available through the FAA website.
- 1.1.5. Survey Standards:** Surveys conducted for design and for construction layout will conform to the requirements of the Surveyor’s Handbook for the subject airport. These handbooks indicate the datum and coordinate system that will be used for the design and construction layout of all projects at the subject airport. Surveyor’s Handbooks are available from the HAS Project Manager.
- 1.1.6.** The effective contract Notice to Proceed date for design services will determine the applicable edition of a code, regulation, standard, amendment, and/or addendum for use on a project. The most updated version is applicable.
- 1.1.7.** If a referenced code, regulation, standard, amendment, and/or addendum is revised prior to permitting, the Designer will advise HAS of any potential impact to the design.
- 1.1.8.** When there is a conflict between two or more codes and standards, the more stringent code applies; the graphic below shows the succession procedure.

Exhibit 1.1-1: Supersession Procedure



1.2. Codes and Standards

1.2.1. All Federal Aviation Administration (FAA) Advisory Circulars (AC) are mandatory.

1.2.1.1. National Fire Protection Association (NFPA)

Code No.	Title
10	Standard for Portable Fire Extinguishers
11	Low Expansion Foam
13	Standard for the Installation of Sprinkler Systems
14	Standard for the Installation of Standpipe and Hose Systems
15	Water Spray Fixed Systems
16	Deluge System
17	Dry Chemical Systems
17A	Wet Chemical Systems
20	Standard for the Installation of Stationary Pumps for Fire Protection
22	Standard for Water Tanks for Private Fire Protection
24	Installation of Private Fire Service Water Mains
25	Inspection for Testing and Maintenance of Water-Based Fire Protection
30	Flammable and Combustible Liquids Code
37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
54	National Fuel Gas Code
58	Liquid Petroleum Gas
70	National Electrical Code (NEC)
72	National Fire Alarm and Signaling Code and Handbook
80	Standard for Fire Doors and Other Opening Protectives
90A	Standard for the Installation of Air-Conditioning and Ventilating Systems
90B	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
91	Exhaust for Air Conveying of Vapors, Gases, Mists
92A	Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
96	Commercial Cooking

101	Life Safety Code
110	Standard for Emergency and Standby Power Systems
291	Recommended Practice for Fire Flow Testing and Marking of Hydrants
400	Hazardous Materials Code
403	Aircraft Rescue and Fire-Fighting Services
407	Standard for Aircraft Fuel Servicing
415	Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways
780	Standard for the Installation of Lightning Protection Systems
900	Building Energy Code
2001	Clean Agent Fire Extinguishing Systems
5000	Building Construction and Safety

1.2.1.2. International Building Code (IBC)

Code No.	Title
NA	International Building Code with COH amendments
NA	International Fire Code
NA	International Green Construction Code
NA	International Energy Conservation Code
NA	Uniform Plumbing Code with COH Amendments
NA	Uniform Mechanical Code with COH Amendments
NA	International Solar Energy Provisions

1.2.1.3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

Code No.	Title
90.1-2013	Energy Standard for Buildings Except Low-Rise Residential Buildings
62.1-2013	Ventilation for Acceptable Indoor Air Quality
52.2-2007	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
55.1-2010	Thermal Environmental Conditions for Human Occupancy
202-2018	Commissioning Process for Building Systems
0-2019	The Commissioning Process
0.2-2015	Commissioning Process for Existing Systems and Assemblies

1.2.1.4. United States Green Building Council (USGBC)

Code No.	Title
NA	Web-based Reference Guide (All Rating Systems) - Annual Subscription
NA	Leadership in Energy and Environmental Design (LEED) Reference Guide for Building Design and Construction

1.2.1.5. Building Owners and Managers Association (BOMA)

Code No.	Title
NA	Office Buildings: Standard Methods of Measurement (American National Standards Institute (ANSI)/ BOMA Z65.1-2010)
NA	Retail Buildings: Standard Methods of Measurement (ANSI/BOMA Z65.5-2010)
NA	Multi-Unit Residential Buildings: Standard Methods of Measurement (ANSI/BOMA Z65.4-2010)
NA	Gross Areas of a Building: Standard Methods of Measurement (ANSI/BOMA Z65.3-2009)
NA	Industrial Buildings: Standard Methods of Measurement (ANSI/BOMA Z65.2-2012)

1.2.1.6. ANSI – TIA/EIA

Code No.	Title
569	TIA Wiring Standards
942	Telecommunication Infrastructure Standard for Data Centers: Telecomm Wiring - Distribution and Performance Package (Includes BICSI TDMM, TIA-526-7, TIA- 526-14, TIA-568.0-TIA-568.4, TIA-569, TIA-570, TIA-598, TIA-606, TIA-607, AND TIA-758)
862	Structured Cabling Infrastructure Standard for Intelligent Building Systems
758	Customer-Owned Outside Plant Telecommunications Infrastructure Standard
607	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
606	Administration Standard for Telecommunications Infrastructure
250	Electrical Performance for Television Transmission Systems
526-14	Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant;
526-7	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

1.2.1.7. Building Industry Consulting Services International (BICSI)

Code No.	Title
5	Outside Plant Design Reference Manual
607	Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications,

006-2015	Distributed Antenna System (DAS) Design and Implementation Best Practices
568B	TIA / EIA 568B - Commercial Building Telecommunications Wiring Standards
569A	TIA / EIA 568A - Communications Building Standards for Telecommunications Pathways and Spaces
13	Telecommunications Distribution Methods Manual, latest edition
005-2016	Electronic Safety and Security (ESS) System Design and Implementation Best Practices

1.2.1.8. Institute of Electrical and Electronic Engineers (IEEE)

Code No.	Title
1100	Recommended Practice for Powering and Grounding Electronic Equipment
142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
802.3	Standard for Ethernet
802.1 AS	Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications
802.1 AQAT	Standard for Local and Metropolitan Area Networks
802.1 QAV	Standard for Local and Metropolitan Area Networks-- Virtual Bridged Local Area Networks Amendment
C 2	National Electrical Safety Code
383	Standard for Qualifying Electric Cables and Splices for Nuclear Facilities

1.2.1.9. American National Standards Institute (ANSI)

Code No.	Title
C80.1	Electric Rigid Steel Conduit
A14.2	Portable Ladder and Scaffolding
A14.7	Mobile Ladder Stands and Mobile Ladder Stand Platforms
A17.1	Safety Code for Elevators and Escalators
C2-2012	National Electrical Safety Code
Z136.1 .2	Safe Use of Lasers and Safe Use of Optical Fiber Communication Systems
Z359.1	Fall Protection Code
X3T9.5	Requirements for UTP at 100MPS
A10.42	Safety Requirements for Rigging Qualifications and Responsibilities

1.2.1.10. Underwriter's Laboratories (UL)

Code No.	Title
6	Electrical Rigid Metal Conduit
514B	Conduit, Tubing, and Cable Fittings
651	Standard for Schedule 40, 80,
1651	Standard for Optical Fiber Cable
2269	Optical Fiber/Communications/Signaling/Coaxial Cable Outlet Boxes
467	Grounding and Bonding Equipment
96	Standard for Lightning Protection
96A	Standard for Lightning Protection installation
1419	Standard for Professional Video and Audio Equipment
1047	Standard for Isolated Power Systems Equipment
1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords
813	Standard for Commercial Audio Equipment

1.2.1.11. American Society for testing and Materials (ASTM)

Code No.	Title
B663	Specification for Electrodeposited Coatings of Zinc on Iron and Steel
A653	Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
A123	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A1011	Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy
A1008	Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability
B 3	Standard Specification for Soft or Annealed Copper Wire
B 8	Specification for Concentric-Lay-Stranded Copper Conductors
B 33	Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes

1.2.1.12. National Electrical Manufacturers Association (NEMA)

Code No.	Title
RN-1	Externally Coated Galvanized Rigid Steel Conduit
TC2	Polyvinyl Chloride (PVC) Conduit of Types EPC-40
TC3	PVC Fittings
250	Electrical Equipment
VE-1-2009	Metal Cable Tray Systems
VE-2-2013	Cable Tray Installation Guidelines

**1.2.1.13. Americans with Disabilities Act Accessibility Guidelines (ADAAG)
Texas Accessibility Standards (TAS)**

Code No.	Title
4.10	Passenger Elevator

1.2.1.14. American Society of Mechanical Engineers (ASME)

Code No.	Title
A17.1	Safety Code for Elevators and Escalators

1.2.1.15. Systemax Structured Cabling Systems performance specifications latest issue and components guide.

1.2.1.16. 2012 International Association of Plumbing and Mechanical Officials (IAPMO) with Houston Amendments.

1.2.1.17. Additional Codes:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Institute of Steel Construction (AISC)
- American Iron and Steel Institute (AISI)
- American Concrete Institute (ACI)
- American Welding Society (AWS)
- International Safety Equipment Association (ISEA)
- Emergency Eyewash and Shower
- Equipment (ISEA Z358.1)

06 - ABBREVIATIONS



06 - Abbreviations

1.1 General

1.1.1. HAS uses Federal Aviation Administration (FAA) and National CAD Standards (NCS) as the primary source of acronyms and abbreviations.

1.1.2. FAA abbreviations list can be found at the FAA’s website.

1.1.3. NCS abbreviation list can be found at the NCS’s website

1.2. Abbreviation

1.2.1. Below is a list of typical abbreviations that will be found throughout this document.

Acronym/ Abbreviation	Full Technical Term	Acronym/ Abbreviation	Full Technical Term
A4A	Airlines for America	AFFF	Aqueous film forming foam
A/C	Air conditioning	AGL	Above Ground Level
AAMA	American Architectural Manufacturers Association	AHJ	Authority having Jurisdiction
AASHTO	American Association of State Highway and Transportation Officials	AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ABA	Architectural Barriers Act	AHU	Air Handling Unit
AC	Advisory Circular	AIP	Airport Improvement Program
ACI	American Concrete Institute	AISC	American Institute of Steel Construction
ACM	Asbestos Containing Material	ALP	Airport Layout Plan
ACR	Air Conditioning and Refrigeration	ANSI	American National Standards Institute
ACT	Acoustical Ceiling Tile	AOA	Airport Operations Area
ADA	Americans with Disabilities Act	API	American Petroleum Institute
ADAAG	Accessibility Guidelines for Buildings and Facilities	APWC	Aircraft potable water cabinet
ADE	Airport Development and Engineering	ARCP	Airport Cooperative Research Programs
ADG	Airplane Design Group	ARFF	Aircraft Rescue and Firefighting
ADWR	Airline Drinking Water Rule	ARI	Air Conditioning and Refrigeration Institute
AEC	Architectural, Engineering and Construction	ARP	Aerospace Recommended Practice
AEP	Annual Exceedance Probability	ASCE	American Society of Civil Engineers

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AFBMA | Anti-Friction Bearing Manufacturers Association AFFF

ASCII | American Standard Code for Information Interchange

Acronym/ Abbreviation	Full Technical Term	Acronym/ Abbreviation	Full Technical Term
ASD	Allowable Stress Design	BT	Bold type
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers	BUG	Backlight, Uplight, and Glare
ASJ	All-service jacket	Btu	British thermal unit
ASME	American Society of Mechanical Engineers ASTM	BUTT	Three-Knuckle Concealed Antifriction-Bearing, Full-Mortise Hinges
ASTM	American Society for Testing and Materials	CAD	Computer-aided design
ATA	Air Transport Association of America	CBIS	Checked Baggage Inspection System
ATC	Air Traffic Control	CBR	California Bearing Ratio
ATR	Automatic Tag Reader	CBRA	Checked Baggage Reconciliation Area
ATS	Automatic Transfer Switches	CCTV	Closed Circuit Televisions
AWG	American Wire Gauge	CCU	Cluster Control Unit
AWWA	American Water Works Association	CDA	Critical Design Aircraft
BAS	Building Automated System	cfm	Cubic foot/feet per minute
BHMA	Builders Hardware Manufacturers Association	CHW	Chilled water
BHS	Baggage Handling System	CLOMR	Conditional Letter of Map Revision CMA
BHSC	Baggage Handling System Contractor	CMA	Change Management Approval
BIDS	Baggage Information Display Systems	COH	City of Houston
BIM	Building Information Modeling	COR	Corbin Russwin Architectural Hardware
BISCI	Building Industry Consulting Service International	CPE	CenterPoint Energy
BMS	Building Management System	CPS	Cathodic protection system
BOM	Bommer Industries, Inc.	CRC	Change Review Committee
BOMA	Building Owners and Managers Association BRS	CRF	Condensation resistance factor
BRS	Baggage Reconciliation System	CSI	Construction Specification Institute
BSD	Baggage Status Displays	CSPP	Construction Safety Phasing Plan

BSG	Building Standards Group	CTA	Central Terminal Area
BSM	Baggage Source Message	CTB	Cement treated base

Acronym/ Abbreviation	Full Technical Term
CWP	Cold working pressure
CUP	Central Utility Plant
DAS	Distributed Antenna System
dB	Decibel
dBA	A-scale decibels
DB	dry-bulb
DBMS	Database Management System
DC	Direct Current
DDC	Direct Digital Control
DFT	Discrete Fourier Transform
DGP	Data Gathering Panel
DHSCBP	Department of Homeland Security Customs and Border Protection
DIP	Ductile Iron Pipe
DLC	Design Lights Consortium
DOAS	Dedicated Outdoor Air System
DOJ	Department of Justice
DOR	The DORMA Group North America
DPWE	Department of Public Works and Engineering DSHS
DSHS	Texas Department of State Health Services
DX	Direct Expansion
EAD	Environmental Affairs Department
EBS	Early Baggage Storage
ECC	Environmental Compliance Checklist
EDS	Explosive Detection System

Acronym/ Abbreviation	Full Technical Term
EFSO	Emergency fuel shutoff
EMT	Electrical Metallic Tubing
EOR	Engineer-of-Record
EP	Ethylene Propylene
EPA	Environmental Protection Agency
EPDM	Ethylene Propylene Diene Monomer
EPIC	Electronic Project Information Cooperation
EPR	Ethylene Propylene Rubber
EPS	Electrical Power Station
ESP	Expanded Services Panel
ESS	Electronic Safety and Security
EUL	Enabling Utilities Landside
EWC	Electric Water Cooler
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FAS	Fire alarm system(s)
FCO	Flight Close-Out
FCU	Fan-Coil Unit
FDA	Food and Drug Administration
FDC	Fire Department Connection
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIDS	Flight Information Display System
FIS	Federal Inspection Services

EFD	Ellington Airport	FM	Factory Mutual
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Acronym/ Abbreviation	Full Technical Term
FOC	Fiber optic cable
Fpm	Feet per minute
Fpy	First pass yield
ft/sec	Foot/feet per second
GFCI	Ground-Fault Circuit Interrupter
GIDS	Gate Information Display System
GIS	Geographic Information System
gpm	Gallons Per Minute
GPU	Ground Power Units
GWB	Gypsum Wall Board
H:V	Horizontal: Vertical
HAG	Hager Companies
HAS	Houston Airport System
HCFCDD	Harris County Flood Control District HEC-HMS
HGL	Hydraulic Grade Line
HHW	Heating Hot Water
HID	High intensity discharge
HMAC	Hot mix asphalt concrete
HMI	Human Machine Interface
HOA	Hand-Off-Auto
HOU	William P. Hobby Airport
HPS	High Pressure Sodium
HSD	High-Speed Diverter
HSLA	High Strength Low Allow
HTHW	High temperature hot water

Acronym/ Abbreviation	Full Technical Term
Hz	Hertz
I/O	Input/output
IAH	George Bush Intercontinental Airport
IAQ	Indoor Air Quality
IATA	International Air Transport Association
IBC	International Building Codes
ICEA	Insulated Cable Engineers Association
ID	Inner Diameter
IDF	Intermediate Distribution Frame
IDM	Infrastructure Design Manual
IEC	International Electrotechnical Commission
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronic Engineers
IESNA	Illuminating Engineering Society of North America
IFC	International Fire Code
IGBT	Insulated-Gate Bipolar Transistor
IPC	International Plumbing Code
ISAT	(TSA) Integrated Site Acceptance Testing
ISD	Inline Screening Device
ISO	International Organization for Standardization
IT	Information technology
ITRP	International Terminal Redevelopment Program
IVE	IVES Hardware; Ingersoll-Rand Company
JIC	Joint Industrial Council
KPI	Key performance indicators

H:V	Horizontal to vertical (ratio)	kV	Kilovolt
HVAC	Heating, Ventilation, and Air-Conditioning	kVA	Kilovolt-amp

Acronym/ Abbreviation	Full Technical Term
kW	Kilowatt
kWh	Kilowatt-hour
LAN	Local area network
LCD	Liquid Crystal Display
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LOMR	Letter of Map Revision
LOTO	Lock-Out-Tag-Out
LPI	Lighting Protection Institute
LR	Light reflectance (value)
LRFD	Load and Resistance Factor Design
M3	Model Map Management
MCK	McKinney Products Company
MCP	Motor Control Panels
MDF	Main Distribution Frame
MDS	Mobile Display System
MEP	Mechanical, Electrical, and Plumbing
MIS	Management Information System
MLIT	Mickey Leyland International Terminal
mph	Mile per hour
MRL	Machine Room-Less
MSS	Manufacturer's Standardization Society
MTM	Main-Tie-Main
M-T-T-M	Main-Tie-Tie-Main
NACE	National Association of Corrosion

Acronym/ Abbreviation	Full Technical Term
NC	Noise Criteria
NCS	National CAD Standards
NDL	No Dollar Limit
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
NGS	National Geodetic Survey
NIC	Noise Isolation Class
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	Nominal pipe size
NSF	National Sanitation Foundation
O&M	Operation and maintenance
O.D.	Outside diameter
OCCS or OmniClass™	OmniClass Construction Classification System
OFA	Object Free Area
OITC	Outdoor-Indoor Transmission Class
ORAT	Operational Readiness and Airport Transfer
OS&Y	Outside stem and yoke
OSHA	Occupational Safety and Health Administration
OSR	On-screen Resolution
PA	Public address
PACS	Primary Airport Control Station
PBB	Passenger Boarding Bridge

	Engineers		
NVAID	Navigational aid	PC	Pre-conditioned
NBPT	No Break Power Transfer	PCA	Pre-conditioned Air

Acronym/ Abbreviation	Full Technical Term	Acronym/ Abbreviation	Full Technical Term
PCC	Portland Cement Concrete	RGS	Rigid Galvanized Steel
PCPM	Policy, Criteria and Procedure Manual	RH	Relative humidity
PDC	Planning, Design, and Construction	RIX	Rixson Specialty Door Controls
PE	Polyethylene	Rms	Root mean square
Pf	Power factor	ROW	Right-of-Way
PFC	Passenger Facility Charges	Rpm	Rotations per Minute
PGDS	Planning Guidelines and Design Standards	RQE	Request to Exit
PICV	Pressure Independent Control Valve	RSA	Runway Safety Area
PLB	Passenger Loading Bridge	RTR	Remote Transmitter Receiver
PLC	Programmable Logic Controller	SACS	Secondary Airport Control Station
POU	Point-of-Use	SAE	Society of Automotive Engineers
PPE	Personnel Protective Equipment	SAR	SARGENT Manufacturing Company
Psf	Pound(s) per square foot	SCADA	Supervisory Control and Data Acquisition
psi	Pounds per square inch	SCH	Schlage Commercial Lock Division
psig	Pounds per square inch gauge	SCR	Silicon Controlled Rectifier
PTFE	Polytetrafluoroethylene	SEER	Seasonal Energy Efficiency Ratio
PTM	Preformed thermoplastic markings	SEL	Schweitzer Engineering Laboratories
PVC	Polyvinyl chloride	SIDA	Security Identification Display Area
PWC	Potable Water Cabinet	SLA	Service level agreement
PWE	Public Works and Engineering	SMACNA	Sheet Metal & Air Conditioning Contractor's National Association
PWL	Percent Within Limits	SOP	Standard operating procedure
PWM	Pulse Width Modulated	SPCC	Spill Prevention, Control and Countermeasure SPCD
PWS	Public Water System	SPCD	Safety Plan Compliance Document
RAS	Registered Accessibility Specialist	SPD	Surge Protection Devices

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RCCP	Reinforced Concrete Cylinder Pipe	SPDT	Single-Pole, Double-Throw
RFID	Radio Frequency Identification	SPRI	Single Ply Roofing Industry
RFV	Request for Variance	SQL	Structured Query Language

Acronym/ Abbreviation	Full Technical Term	Acronym/ Abbreviation	Full Technical Term
SSS	Sanitary Sewer Systems	VAC	Volts alternating current
SSTP	Site-Specific Test Plan	VAV	Variable Air Volume
STA	Stanley Commercial Hardware	VC	Vinyl Composition
Standards	Design Standards	VDC	Volts of direct current
STC	Sound Transmission Control	VDGS	Visual Docking Guidance System
SU	Single-Unit	VFD	Variable Frequency Drives
SUE	Subsurface Utility Engineering	VOC	Volatile organic compound
SWPPP	Stormwater Pollution Prevention Plan	VRLA	Valve-Regulated Lead-Acid
TCEQ	Texas Commission on Environmental Quality	VSR	Vehicle Service Road
TDLR	Texas Department of Licensing and Regulation	WAN	Work Area Notification
THD	Total Harmonic Distortion	WB	Wide Body
THW	Thermoplastic, heat and water (resistant wire)	Wg	Water gauge
TPDES	Texas Pollutant Discharge Elimination System	XML	Extensible Markup Language
TPO	Thermoplastic Polyolefin	YAL	Yale Commercial Locks and Hardware
TRB	Transportation and Research Board	IDO	Infrastructure Division Office
TRR	(TSA) Test Readiness Review	VRF	Variable Refrigerant Flow
TSA	Transportation Security Administration	GPF	Gallons per Flush
TxDOT	Texas Department of Transportation	fc	Foot Candles
UF	Underground feeder	Cx	Commissioning
UL	Underwriters' Laboratories, Inc.	CxA	Commissioning Authority
Um	Micrometer	CxM	Commissioning M
UMC	Uniform Mechanical Code		
UNO	Unless Noted Otherwise		
UPC	Uniform Plumbing Code		

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UPS	Uninterruptible Power Supplies		
USGBC	United States Green Building Council		
UST	Underground Storage Tanks		

07 - PREPARATION OF PROJECT MANUALS



07 - Preparation of Project Manuals

Part 1 – General

1.1. Overview

- 1.1.1. The purpose of this document is to assist the Project Design Consultant (Designer) in the appropriate use of the Houston Airport System (referenced hereinafter as “HAS”) specifications, forms and other related bid documents on HAS Projects. The Designer shall prepare the Project Manual as instructed within this Design Standard.
- 1.1.2. The Designer shall prepare the Project Manual in accordance with the current edition of The Construction Specifications Institute (CSI) Manual of Practice and MasterFormat Master List of Titles and Numbers for the Construction Industry except to the extent this Design Standard departs from those recommendations.
- 1.1.3. **Design Milestones:** Design review submittals are required at 30 percent, 60 percent, 90 percent and 100 percent levels of completion or as required for each specific project. This Standard provides specific information on the requirements and level of detail required for each of these submittals.
- 1.1.4. Some documents referenced herein require completion or modification to suit the individual project. Other documents must be reproduced directly, without alterations of any kind, and are identified in this Standard.
- 1.1.5. The Designer will be responsible for the content of the entire Project Manual as issued for bids and the professional's seal will be applicable to all Contract Documents, including those specification sections supplied by HAS. Include and locate professional licensing seals per Texas licensing board requirements.

Part 2 - Project Delivery Methods

2.1. General

- 2.1.1. During the Project Pre-Design Stage, HAS will select the appropriate project delivery method. The project delivery method will determine the contract type and methodology for organizing the Project Manual. Refer to ‘Attachment A’ to this standard, Project Manual Organization, for an index of documents and an explanation of how the documents are to be organized within the Project Manual in accordance with the project delivery method and associated contract type.
- 2.1.2. Since some documents are not required to be issued with every Project Manual, the Designer must thoroughly review these instructions and coordinate directly with the HAS Project Manager prior to assembling the Project Manual. HAS construction projects will typically fall under one of the following project delivery methods:
 - Job Order Contracting (JOC)
 - JOC allows HAS to expedite numerous, commonly encountered projects through a single, competitively bid contract. JOC reduces unnecessary levels of engineering, design, and contract procurement time along with construction project procurement costs by awarding multi-year contracts to various contractors for a wide variety of renovation, repair and construction projects.
 - HAS hires a Designer to prepare the construction documents and then awards the construction contract to the JOC contractor to perform the work.

- Competitive Sealed Proposals (CSP)
 - CSP methodology, HAS contracts directly with the Designer and then issues a Request for Proposals (RFP) to select and negotiate a contract with a contractor based on pre-established selection criteria. The RFP includes construction documents, contractor selection criteria, estimated budget, project scope, schedule, and other necessary information.
 - Upon receipt of bids, HAS determines which bidder represents the best value to the Airport based on the published selection criteria and resultant ranking.
- Construction Manager-at-Risk (CMAR)
 - Under a CMAR contract delivery method, HAS selects a Designer under a separate procurement process to prepare the project construction documents. The CMAR is selected under a one or two-step process, where HAS prepares and publishes a Request for Qualifications (RFQ) and may be followed by an RFP to those firms qualified to progress to the RFP stage. Selection is based on the proposal which offers the best value to the Airport.
 - The CMAR provides pre-construction (design) and construction phase services for a fee and acts as a general contractor to deliver the work within a Guaranteed Maximum Price. The CMAR must publicly advertise and solicit either competitive bids or competitive sealed proposals from trade contractors and subcontractors.
- Design-Build (DB)
 - Under a Design/Build contract delivery method, HAS prepares and publishes a Request for Qualifications (RFQ) followed by an RFP to those firms qualified to progress to the RFP stage. Design/Build teams are comprised of a general contractor, architect, and engineering consultants. HAS contracts directly with the contractor under this project delivery method. To procure trade contractors and subcontractors, the DB firm must publicly advertise and solicit either competitive bids or competitive sealed proposals.

Part 3 - Application of Bidding Requirements and Contract Form

3.1. General

- 3.1.1.** Documents outlining the contractual terms and conditions of the construction contract are placed at the beginning, or front end, of the Project Manual. They are followed in order by the technical construction specifications. For this reason, the contractual terms and conditions are often referred to as the “Front End” documents. Front End documents include:
- HAS Bidding Requirements and Contract Forms
 - HAS Supply Chain Management Department of the HAS Infrastructure Division maintains these documents. For contractor solicitation, HAS will post these documents with the procurement solicitation on the HAS procurement website.
 - Conditions of the Contract
 - Includes the Uniform General Conditions and Supplementary Conditions and Division 00 documents.
 - Conditions of the Contract are subject to revision at any time. Therefore, the Designer shall verify applicability of the documents with the HAS Project Manager before preparing the Project Manual.

3.2. HAS Bidding Requirements and Contract Forms

3.2.1. Request for Bids/Proposal:

- HAS will prepare the Request for Proposal with draft agreement to solicit the contractor under Competitive Sealed Bidding and Competitive Sealed Proposal project delivery methods.
- HAS will prepare the RFQ and RFP with draft agreement for CMAR and DB Firm solicitations.

Part 4 - Application of Division 01 Specifications - General Requirements

4.1. General

- 4.1.1.** Designer will organize the Project Manual in accordance with requirements described herein and based on industry standard for the various project delivery types.
- 4.1.2.** For CMAR and DB trade contractor or subcontractor solicitation, HAS will furnish Division 01 documents directly to the Designer for preparation of the Project Manual.

Part 5 - Application of Technical Specifications (Divisions 02-48)

5.1. General

- 5.1.1.** It is the responsibility of the Designer to furnish specifications written to meet specific Project requirements and that adhere to the HAS Design Standards. Specifications furnished by the Designer must be submitted for HAS review and approval prior to issuance in the Project Manual.
- 5.1.2.** Where the Designer considers that compliance with any requirement stated within the HAS Design Standards is not feasible or advisable, the Designer will communicate such concerns to the HAS Project Manager in sufficient time to allow resolution during the Project Design Development Stage and to meet contract schedule obligations.
- 5.1.3.** In general, the Designer will use the HAS Standards for new construction and redevelopment or renovation projects within existing HAS facilities.

5.2. HAS Review Process

- 5.2.1.** Designer will transmit draft Specifications in electronic pdf format with proposed language for HAS review during various Design Stage Submittals as indicated in the Design Consultant Agreement. Designer will resolve all HAS review comments and incorporate all necessary revisions prior to submission to the HAS for final design review. The final design review Specification submittals shall be clean copies, free of hidden, instructional, shaded, highlighted, bold, and/or strike through text.

Part 6 - Creating and Editing Specifications

6.1. General

6.1.1. Criteria required for all specifications included in the Project Manual.

- Electronic Format: Microsoft Word
- Specification Organization: Follow the Construction Specifications Institute (CSI) MasterFormat and Section Format for the basic layout of Divisions 00 through 48.
- Formatting: HAS will provide Division 00 and 01 to the Design consultant upon issuance of a Project requirement from the asset Manager..
- Font, including header and footer: Arial - 12pt.
- If a PART is not to be used in a Specification, (e.g. PART 2 PRODUCTS), enter “Not Used” under the heading.
- At the end of the last specification section included within the Project Manual, include both “END OF SECTION ## ## ##” and “END OF SPECIFICATIONS”.

6.2. Cover Pages

6.2.1. A typical cover page has the following elements centered on the page:

- Houston Airports Logo
- “City of Houston – Department of Aviation – Infrastructure Division
- PROJECT MANUAL
- [LEGAL PROJECT NAME]
- [PROJECT LOCATION]
- PROJECT NO.:{XXX/X}
- CIP NO.: [A-XXXX]
- [AIP NO.: 3-48-0111-XX]
- [VOLUME NO. OF TOTAL VOLUMES]
- DIVISION 00 – 48
- [ISSUE MONTH/YEAR]

6.2.2. In the lower right corner please include the “Designer Seal”.

6.2.3. In the lower left corner please include the Designer Firm Name, Designer Street, Designer City/State/Zip, and the Designer Telephone Number.

6.3. Headers and Footers

6.3.1. Typical Header: Designer will edit the header to suit the Project.

Left Side		Right Side
Project location Project Name		SECTION TITLE
Project number		

6.3.1.1. Below is an example of the header.

Left Side	Right Side
IAH Mickey Leland International Terminal PN-XXX	SUMMARY OF WORK

6.3.2. Typical Designer Specification Footer: Designer must include the applicable CSI Section Title and Number.

Middle of Footer
SECTION TITLE Section ##### - Page #

6.3.2.1 Below is an example of the footer.

Middle of Footer
SUMMARY OF WORK 01110 - 1

6.3.3. If a PART is not to be used in a Specification (e.g. a PART 2 PRODUCTS or PART 3 EXECUTION) enter “Not Used” under the heading.

6.3.4. At the end of the last Specification Section included within the Project Manual, include both “END OF SECTION ## ## ##” and “END OF SPECIFICATIONS”.

Part 7 - Attachment A: Project Manual Organization

7.1.1. The Designer will organize the Project Manual in accordance with HAS requirements. The HAS Project Manager will provide a list of documents.

21 - BAGGAGE HANDLING SYSTEMS



21 - Baggage Handling Systems

Part 1 – General

1.1. Overall

- 1.1.1.** All Baggage Handling System (BHS) project content will be designed to meet the requirements of airline baggage handling and must adhere to industry standard practices for the safe and efficient transport, sorting, and delivery of standard airline baggage tubs and baggage having characteristics as outlined in Baggage characteristics section, worker safety, durability, reliability and operational efficiency.
- 1.1.2.** Designers must produce drawings and specifications that describe in detail the requirements for a Baggage Handling System Contractor (BHSC) to design, develop, manufacture, install, test and commission a complete (turn-key) BHS. The system must include a Checked Baggage Inspection System (CBIS) that complies with Houston Airport System (HAS) requirements and the latest version of the Transportation Security Administration (TSA) Planning Guidelines and Design Standards (PGDS) available online on the TSA website.
- 1.1.3.** Designers must assure compliance with the mandatory requirements of the TSA PGDS. If conflicts arise, the PGDS will govern until an approved Request for Variance (RFV) is received from TSA.
- 1.1.4.** Designers must comply with best practices and industry standards, with guidance from the latest version of the TSA PGDS, and will submit a written explanation that justifies the basis for any deviation to HAS for approval.
- 1.1.5.** The BHS will interface with HAS infrastructure, including but not limited to, the buildings' Fire Systems, Airline Reservation Systems, Flight Information Display Systems (FIDS), Baggage Information Display Systems (BIDS), Gate Information Display Systems (GIDS) and Baggage Reconciliation Systems (BRS).
- 1.1.6.** The BHS will include a control room (HAS IT Standards, cabling, uninterruptible power supplies [UPS] Division 27), sort controller, host interface, internet-based reporting, graphics and monitoring system that includes all related redundant computer and network equipment. A fully integrated Baggage Handling System will provide but not limited to the following functionality:
 - Flight schedule and flight schedule management
 - Graphical reports
 - Operator interface
 - Supervisory control
 - Equipment control
 - Manual encode (If Required)
 - Baggage source messaging
 - Bag tracking and tracing
 - Flight information interfaces
 - Bag tag scanner interface
 - Bag tag translation
 - Early bag storage and retrieval (If Required)

- Baggage reconciliation

1.2. Quality Assurance

- 1.2.1. All subsystems will be available no less than 99.5 percent of the time, as calculated monthly. The maximum allowable downtime in a single operating day is no more than 15 minutes on one subsystem. Cumulative daily downtime for all subsystems will not exceed 20 minutes.
- 1.2.2. No more than one Programmable Logic Controller (PLC) failure per month is permitted. The maximum downtime for such a failure is 10 minutes per year.
- 1.2.3. Tracking accuracy will be maintained at a minimum of 99.5 percent where baggage tracking is required. This percentage will be calculated using the total number of bags input to the baggage system each month.
- 1.2.4. The CBIS will be designed to incorporate International Air Transport Association (IATA) format bag tag identification and will have a read rate of no less than 95 percent for laser arrays, Automatic Tag Readers (ATRs) and 99 percent for Radio Frequency Identification (RFID).
- 1.2.5. The CBIS will be capable of processing checked bags with a time in the system that will be 10 minutes or less for 95 percent of the peak hour bags.
- 1.2.6. The system will perform with less than 0.5 percent of the total bag volume activating the fail-safe alarm functionality.
- 1.2.7. Bag spacing within the CBIS will be optimized to establish and maintain, prior to the entrance of each Explosive
- 1.2.8. Detection System (EDS) machine, the bag spacing requirements as defined by the EDS technology in use. This gap will be adjustable.
- 1.2.9. The BHS equipment will not produce or induce objectionable vibrations into the building. The BHS will incorporate any and all necessary vibration isolation devices or techniques required to meet specific vibration limits in the detailed specifications.
- 1.2.10. The BHS equipment will not generate noise that would be annoying or harmful to the public or employees. This requirement applies to all equipment in public areas, sort areas, make-up areas, and areas used for manual encoding of baggage.

1.3. Shop Drawings and Submittals

- 1.3.1. The Designer will submit documentation including, but not limited to drawings, tables, and calculations add in specifications, functional specification, test plans, O&M Manuals etc. to HAS and the TSA for review and acceptance prior to progressing each design stage to the next level.
- 1.3.2. The Designer will coordinate with the HAS Project Representative the submittal requirements of Chapter 2 of the TSA PGDS, including a Basis of Design Report and Construction Work Estimates.

1.4. Warranty

- 1.4.1. Warrant the baggage handling system for two years against defective parts and labor from the date of beneficial use of the baggage handling system, and for five years against defective design beginning on the final acceptance date of the complete baggage handling system.

- 1.4.2.** The BHSC will provide 60 days of on- site support (one hour before operational hours and throughout the operational day) after conditional acceptance by a qualified technical representative capable of facilitating troubleshooting and correcting problems that may occur to the system during this period. This requirement includes all aspects of the BHS and the BHS's connections to the EDS systems, from mechanical, electrical, PLC and computer equipment to all the operational applications, programs and processes developed for the project.

Part 2 – Products

2.1. Conveyors

- 2.1.1.** The BHS will safely and successfully transport many different forms of baggage. Normal items that can be processed by the equipment without special handling include golf bags, garment boxes and duffel bags. The standard conveyors and sort devices will be designed to convey and sort baggage up to 54 inches long. Out-of-gauge items may be conveyable on standard conveyors but are too long and high to pass through the EDS machines. These items are measured by photocells and are separated off to the out-of-gauge line before the EDS divert points. The specified length and height dimensions for out-of-gauge baggage must be obtained from the EDS provider. Oversize items such as map cases, skis and other materials that cannot be handled by the equipment must be placed on specially designed oversize BHS or manually transported to the baggage make up area. Fragile items such as garment bags, hat boxes, bowling balls, shopping bags and other materials will be processed as normal baggage when contained in airline tubs.

- 2.1.2.** Typical Conveyor Equipment Loads are as follows:

2.1.2.1. Standard Conveyor Equipment Load (live and static): 100 pounds per linear foot

2.1.2.2. Oversize Conveyor Equipment Load (live and static): 150 pounds per linear foot

- 2.1.3.** Typical Conveyor Specifications are as follows:

2.1.3.1. Maximum Standard/Oversize Conveyor Length (5 foot drive): 60 feet

2.1.3.2. Maximum Standard Conveyor Length (mini drive): 15 feet

2.1.3.3. Minimum Standard/Oversize Conveyor Length (queue belt): 3 feet 6 inches

2.1.3.4. Standard Conveyor Width (no drive equipment): 3 feet 6 inches

2.1.3.5. Standard Conveyor Width (including drive equipment): 4 feet 6 inches

2.1.3.6. Oversize Conveyor Width (no drive equipment): 5 feet

2.1.3.7. Oversize Conveyor Width (including drive equipment): 6 feet

2.1.3.8. Standard/Oversize Height (including right- of-way): 5 feet

2.1.3.9. Nominal Incline/Decline Slope (non- tracking): 12 degrees

2.1.3.10. Maximum Incline/Decline Slope (non- tracking): 18 degrees

2.1.3.11. Nominal Incline/Decline Slope (tracking): 7 degrees

2.1.3.12. Maximum Incline/Decline Slope (tracking): 12 degrees

- 2.1.4.** Typical Power Turns and Spirals Specifications are as follows:

2.1.4.1. Power Turn Inside Radius (standard): 4 feet

2.1.4.2. Power Turn Outside Radius (standard): 7 feet 9 inches

2.1.4.3. Power Turn Inside Radius (oversize): 6 feet

2.1.4.4. Power Turn Outside Radius (oversize): 11 feet 5 inches

- 2.1.4.5. Spiral Drop (maximum): 1 foot per 45 degrees
- 2.1.4.6. Spiral Drop (tracking): 6 inches per 45 degrees
- 2.1.5. Queue conveyors will be equipped with a minimum of a two-horsepower drive.
- 2.1.6. Queue conveyor belts will be positively tracked utilizing a snub roller. Guided belt designs will be submitted and approved by HAS.
- 2.1.7. Power turns will be equipped with positive drive components. Friction drive power turns will be submitted and approved by HAS.
- 2.1.8. Typical Drive Aisles Specifications are as follows:
 - 2.1.8.1. One-way drive aisle width 15 feet (as existing building permits)
 - 2.1.8.2. Bypass Aisle: 10 feet (as existing building permits)
 - 2.1.8.3. Clear Height: 10 feet
 - 2.1.8.4. Cart/Container Staging (parallel): 7 feet

2.2. Function

- 2.2.1. The BHS will incorporate an automated sorting system composed of a set of redundant computers, switches, input devices and peripherals connected on a private BHS local area network. This network interfaces to the HAS Host Computer through the Sort Controller Subsystem. The Human-Machine Interface (HMI) to the BHS and the automated sorting system is the BHS Workstation. Key components of the Sorting System network are:
 - 2.2.2. **System Redundancy:** The BHS will be designed and implemented in such a way that no single failure will affect system functionality. No single system or component failure will cause a system shut-down.
 - 2.2.2.1. **Baggage Tags:** Automated sorting systems require positive identification of bags prior to input into the BHS using 10-digit IATA license plate tags, 10-digit IATA license plate fall back tags, sort pier tags, RFID tags or some combination thereof.
 - 2.2.2.2. **Tag Identification Devices:** Tag identification devices must identify all bags input into the BHS before the bags can be directed and routed to a sort destination. These tag identification devices may include scanner arrays, RFID antennae, manual encoding consoles and hand-held scanners.
 - 2.2.2.3. **Sort Controller Subsystem:** The subsystem must be a fully redundant computer system that manages all sorting activities for the BHS, including interfacing to the HAS Host Computer, the BHS PLC network, and the Tag Identification Devices.
 - 2.2.2.4. The Database Management System (DBMS) defined in the Specification for Statistical Analysis, performance metrics and historical reference will be processed on a server separate from the sort controller.
 - 2.2.2.5. **DBMS Tables:** Some data tables required for sorting are maintained on the Sort Controller Subsystem server(s). Statistical evaluation of system performance maintained in database tables will be processed on a server separate from the sort controller.
 - 2.2.2.6. The sort controller will only provide the PLC information to sort baggage.
 - 2.2.2.7. **BHS Workstation:** Computers, monitors, printers and applications software that provide the HMI to the BHS, including supervisory data processing activities, the system status monitor and system maintenance utilities.
 - 2.2.2.8. **System Status Monitor:** Applications software running on the BHS Workstation provides a graphical depiction of the BHS activities, alarms and other events.
 - 2.2.2.9. **PLC Network:** PLC network controlling the BHS is also used to execute routing and tracking activities as part of the automated sorting system. The PLCs execute sort commands received from the Workstation, and report system status, events and other statistical data back to the

Workstation. The Tag Identification Devices are also connected directly to the PLC via an additional module.

2.2.2.10. HAS Host Computer: The HAS Host Computer provides the automated sort system Workstation with passenger and flight information, including the Baggage Source Message (BSM) necessary to properly sort baggage to the proper destination.

2.2.2. Transmission of data will be via Structured Query Language (SQL), American Standard Code for Information Interchange (ASCII), or other similar means of communications. The Designer will coordinate with the BRS Vendor and the Engineer for all the interface and functionality requirements. The BHS BRS interface will be capable of receiving Extensible Markup Language (XML) data for updating bag tag information.

2.2.3. The BHS will be capable of recognizing objects placed in the system by reading or otherwise identifying baggage tags conforming to one or more of the following standards:

2.2.3.1. IATA 10-Digit License Plate Bar Coded Tags: The BHS will be capable of reading baggage tags conforming to the applicable recommendations of IATA Resolution 740- Form of Interline Baggage Tag.

2.2.3.1.1. The bar-coded portion of the baggage tag is a 10-digit number containing a 1-digit functional identifier, a 3-digit airline code, and a unique 6-digit index number.

2.2.3.1.2. The baggage tag will conform to the quality guidelines of IATA Recommended Practice 1740A.

2.2.3.1.3. IATA tags are scanned and read by optical tag identification devices such as scanner arrays and hand-held scanners.

2.2.3.1.4. In the event a bag has a 10-digit IATA license plate tag and a fallback sort tag, the valid 10-digit IATA license plate tag will take precedence.

2.2.3.2. IATA License Plate Fallback Sort Tags: The fallback tag will conform to IATA Recommended Practice 1740b License Plate Fallback Sort Tag.

2.2.3.2.1. The bar-coded portion of the fallback tag is a 10-digit number containing a 1-digit functional identifier, a 3-digit airline code, a 4-digit numeric location for the sort station, and a 2-digit pier/lateral/chute indicator.

2.2.3.2.2. Fallback sort tags are used when communications from the HAS Host Computer are interrupted and BSMs are not available to the Sort Controller.

2.2.3.2.3. IATA fallback tags are scanned and read by optical tag identification devices such as scanner arrays and hand-held scanners.

2.2.3.2.4. The Sort Controller will use a combination of airline code and pier number to provide additional sorting options.

2.2.3.2.5. The Fallback Tag will be verified to ensure that the 4-Digit Airport Code is valid for the airport sorting the tag.

2.2.4. The Designer will obtain a copy of the latest versions of the IATA Recommended Practice 1745, IATA Resolution 740, and conform to the format requirements contained within.

2.2.5. The BHS Bag ID, used for tracking purposes, can use an alternate ID or the original bag's 10-digit IATA Bag Tag number read by the ATR.

2.2.6. The BHS controls will maintain the relation between an alternative tracking ID and

2.2.7. the IATA Bag Tag for all bags that are successfully read. The data from the 10-digit IATA Bag Tag will be used as the Primary Bag Identification passed from the BHS to the Inline Screening Device (ISD). CBIS tracking will in no way be controlled or constrained by a sort controller where the relation is maintained within the PLC.

2.2.8. If five bag tags in a row, configurable, for a flight is read by the ATR, but cannot be correlated to a

flight number in the sort table display (i.e., the flight was not downloaded by FIDS), an alarm message will be issued. The message will state that “Flight Number XXX Not Found.” The BHS control room operator then can either manually enter in the flight details or request another FIDS download/update.

- 2.2.9.** The BHS Bag Identification and, if available, the Bag Tag Identification will be transferred between BHS and EDS equipment. This is defined by each EDS manufacturer’s interface requirements document or integration guide. The IATA Bag Tag will be the primary means of bag to image association.
- 2.2.10.** The BHSC is responsible for the interface between the EDS machines and the BHS. This includes mechanical equipment, electrical devices, and computer/PLC- based hardware and software. The wiring, cabling and communication devices required for these two systems to interact are the responsibility of the BHSC.
- 2.2.11.** EDS Vendor Documentation:
- Site Planning and Design Guide
 - Integration Guide
 - BHS Interface Information
 - Operating Instructions
- 2.2.12.** The maximum acceptable bag jam event rate is one percent. This is calculated by taking the total number of bag jam events divided by the total number of bags in a 24-hour period. CBIS designs will include measures to facilitate the quick and effective clearing of any bag jams.
- 2.2.13.** The BHSC will provide the means and methods, prior to the EDS machines, to align baggage on the feed conveyors before they enter the EDS machines. The result must be a smooth, efficient and jam-free placement of baggage into the machines. The BHSC will coordinate with the EDS machine provider and accommodate the EDS specifications to ensure that baggage placement requirements are met.
- 2.2.14.** Enough Level 2 On-screen Resolution (OSR) travel time must allow for 45 seconds of decision time for the OSR operator.
- 2.2.15.** There must be an appropriate number of queuing conveyors upstream of the EDS devices. This is to absorb surges in baggage demand throughout the day. Current design provides a minimum of seven queue conveyors upstream of the Level 1 EDS device.
- 2.2.16.** Anti-gridlock PLC logic will be executed for the system to ensure a smooth and efficient transfer of baggage from one conveyor to another. This includes a comprehensive approach to the larger system that creates the highest throughput rate for baggage in all sections of the BHS.
- 2.2.17.** The BHS will interface directly with the building fire system (via the HAS network). The Designer will coordinate with the Fire Marshal for the location of all fire zones. In addition to the fire zones, the Designer will need locations for the shutdown of conveyors and fire doors impacted by a fire alarm. Fire doors will be provided with a fusible link which, when broken, will also cause the door to close.
- 2.2.18.** The Designer will coordinate the specific origin of the BRS information and requirements.
- 2.2.19.** The BHS Workstation is the HMI to the BHS automated sorting software and hardware. The HMI provides personnel with operational, diagnostic and maintenance access to the Sort Controller, the System Status Monitor and the DBMS. This includes manual intervention into the fully automatic, real-time functions of the BMS system and its computer software and hardware, report generation and software maintenance activities.
- 2.2.19.1. Menu Driven:** The HMI will be a browser- based, remotely accessible application suite that provides menu-driven access for report generation, DBMS table maintenance, BHS local area network (LAN) maintenance and customary user activities. Typical operator activities

based on user access rights include the following.

- 2.2.19.1.1. **Add/Edit/Delete Flight Information:** This allows the operator to add, edit and delete flight information.
- 2.2.19.1.2. **Hold/Release Flight or Flights, by Flight or for All Flights:** The hold capability allows the operator to suspend all flight close-out functions for a selected flight or for all flights. Release flight or flights resumes normal close-out function. All flights that would have closed out during the period that the “hold” was in effect must record late bag or locked out bag counts beginning at time of the release command.
- 2.2.19.1.3. **Close An Open Flight:** This allows an operator to Close a flight manually. Flight Close is normally done automatically by a Flight Close-Out (FCO) message from the HAS Host Computer to the Sort Controller. This event will be logged.
- 2.2.19.1.4. **Reassign a Sort Device:** This allows the operator to assign all bags going to any sort device to be reassigned to another sort device. This will cause the reassigned sort device to be Out of Service. Piers cannot be reassigned to an Out of Service pier or to themselves.
- 2.2.19.2. **Save/Load Current Flight Table:** This permits the operator to save the current flight table to an alternate device (such as a removable media or a network storage device).
- 2.2.19.3. It also allows the operator to load a flight table from an alternate device (such as removable media or a network storage device) and overwrite the current flight table.
- 2.2.19.3.1 **Edit/Save/Load Offline Flight Table:** This allows the operator to call up and edit/save/load an offline flight table, without affecting the current online flight table contents.
- 2.2.19.3.2 **View System Status:** This permits the operator to view/print a system status log for any of the previous 365 days.
- 2.2.19.3.3 **Clear All Statistics:** This allows the operator to clear all daily statistics.
- 2.2.19.3.4 **Change System Date/Time:** This allows the operator to reset the date/ time on all outbound baggage handling system network devices.
- 2.2.19.3.5 **Change System End of Day Time:** This allows the operator to change the time that the system end-of-day will occur.
- 2.2.19.3.6 **Set No-Read Limits:** This enables the operator to change the preset no-read limits for each scanner array in the sort controller.
- 2.2.19.3.7 **Set Domestic and International Flight Windows:** This enables the operator to set the initial values of Flight Open, Close Time and Flight Lock-out as offsets from Flight Departure time. These values will determine the initial value of flight Open and flight Close times when adding a flight by manual or automated means.
- 2.2.19.3.8 **BSM Traffic Suspect and Failed Levels:** This allows the operator to set the threshold levels for triggering a BSM Suspect warning event and a BSM Failed event. These values are used to trigger events when consecutive IATA tags are read that do not have a corresponding BSM message (bag table entry).
- 2.2.19.3.9 Configure email receipts for Automatic End-of-Day report distribution.
- 2.2.19.4. **Configure Periodic and EOD Reports:** The BHSC will provide a method to set the characteristics of each report and error message generated by the system. This includes flags or settings for manual and automatic generation of reports, and archiving, printing, email distribution, time intervals for automatic printing.
- 2.2.19.5. **Automatic Database Table Maintenance:** End-of-Day will trigger automatic processing and maintenance of the following data:
 - 2.2.19.5.1. Clear all statistics
 - 2.2.19.5.2. Reset all temporary sort device reassignments
 - 2.2.19.5.3. Delete all bags over three days old
 - 2.2.19.5.4. Prepare the Active flight table

2.2.20. Reports can be requested at any time during the operational day as a menu selection from the Workstation Operator Interface. Reports contain data about the current day's activities and data or archived fault log data. All reports will be archived for viewing/analysis for at least one year. Report data will be archived and available in a format that may be exported for external application analysis. Any report viewable on screen may be optionally printed to the report printer.

2.2.21. The BHS will be capable of producing configurable, real time reports in the specified format, including but not limited to:

- Sort order
- End of day
- Baggage tag
- Flight information
- Sort device reassignment
- Fault log
- Scanner array activity
- Sort rate
- Manual encoder activity
- Sort device activity
- Out-of-gauge
- Flight bag count
- Carrier report
- Photocell report
- Sorting device
- Equipment report
- Jam statistics
- Throughput report
- Shaft encoder
- Default report
- Bags for flight report
- Bags for pier
- Bags for city

2.3. Flexibility

2.3.1. Provide multiple flow paths to allow continued operations despite equipment failure or demand surges.

- 2.3.2.** Provide default capability (anti-grid lock) to ensure that in the case of subsystem saturation, an alternative/backup processing path or discharge point is available. In no case will total system saturation occur.

2.4. Serviceability

- 2.4.1.** Design, construction, and installation of the BHS equipment will provide maximum accessibility and convenience for inspection, adjustment, lubrication and all other maintenance and operating requirements. Suitable doors or removable enclosures will be provided within the actual conveyor equipment for this purpose. The Contractors will provide access points within the building structure based on size and location information as provided by the BHSC.
- 2.4.2.** Conduit runs will be mounted so they do not restrict maintenance access to BHS equipment, conveyors, and system/conveyor components that may require servicing. Conduit runs will not be mounted on outer radius sideguards or perimeter chain guards of power turns, nor on merge conveyor sideguards.
- 2.4.3.** Design criteria will include provisions for access to parts and components requiring maintenance and service. Configuration and replacement requirements will address the goal of no more than two maintenance personnel servicing or replacing a part or component in a period not to exceed two hours.
- 2.4.4.** Precedence of maintenance access will take priority over fabrication, manufacturing, and installation techniques. Disassembly of components that are not directly involved with the repair or replacement of the affected parts should not be necessary during the repair or servicing functions. The BHS will provide maximum accessibility for the repair or replacement of parts or assemblies in lieu of parts, or other removable and replaceable equipment items without having to move, remove, or dismantle associated equipment, other equipment, or structural items in the area.
- 2.4.5.** Lubrication fittings, lubrication manifolds, electrical controls, etc., will be located wherever possible with maximum access as a prime design objective. This will also mean that in areas where there are catwalks, the drive assemblies, motor safety disconnect switches, photocells, limits switches, control stations, etc., must be mounted so that they are readily accessible from the catwalk.
- 2.4.6.** In areas where the underside of the BHS equipment or conveyor section is inaccessible, the BHS will provide means of access on both sides of the equipment or conveyor for maintenance purposes.
- 2.4.7.** Typical clearances for building elements (as required by conveyor components and baggage) will be as follows:
- 2.4.7.1.** Overhead: 36 inches from top of belt
- 2.4.7.2.** Lateral 1 foot along walls and 6 inches along columns.
- 2.4.7.3.** Underneath as required for maintenance.
- 2.4.8.** All outbound conveyor subsystems are to be controlled by centralized PLCs with “warm” backup for redundancy. Warm Back-Up: In the event of a primary component failure (e.g., PLC) the warm backup has to be manually switched to become the primary component.

2.5. Durability

- 2.5.1.** The expected operating life of baggage handling systems provided by the BHSC under this Standard will be 15 years under normal operating and maintenance conditions. Normal operating conditions

are considered to be 18 hours per day, 365 days per year.

2.6. Sustainability

- 2.6.1. HAS maintenance personnel must be able to easily modify/add subsystems, display faults, and modify/add reports to the designed and installed Maintenance Diagnostic System (MDS), in the event that additional/modified subsystems are installed as part of any future project.
- 2.6.2. The BHS will incorporate manual encode consoles that are easily interchangeable/ replaced, if required, and require minimum software changes/modifications.
- 2.6.3. The Designer will strive to design the BHS to be easily and economically enhanced to meet requirements over the next 15 years. Easily removable conveyors are required to ensure EDS devices can be removed and replaced, if required.
- 2.6.4. Selected motors will have min IE5 efficiency rating (Provide alternate price for IE4)+.

Part 3 – Execution

3.1. Installation

- 3.1.1. All site work will be coordinated and performed so there is minimal impact to airline and airport related operation. Removal of, modifications to, or replacement of any equipment and installation of new equipment and associated tie-in to outbound baggage handling systems must be carefully coordinated with the airlines and site TSA personnel and accomplished during periods coordinated with other construction and installation phasing.
- 3.1.2. All installation of the BHS and its conveyor equipment will meet the licensing requirements in force at the project site.
- 3.1.3. The BHSC will obtain any and all work and job permits and security badges that are required for BHSC personnel and installation crews as well as for any subcontractors used by the BHSC.
- 3.1.4. The BHSC is responsible for obtaining and paying for any and all building permits, licenses, building/system inspections, professional seals, etc., required for the project site and the installation of the BHS.
- 3.1.5. The BHSC is responsible for providing any and all temporary power and lighting that may be required for and during the course of the installation of the BHS.
- 3.1.6. **Engineering Stamps:** Drawings will be properly stamped and sealed by a Professional Engineer registered in the State of Texas when required by state and local code. This will include structural attachment detail drawings and power distribution point calculations.
- 3.1.7. The Designer will coordinate the baggage handling system's total system horsepower, amperage (based on full load nameplate data), total electrical service requirements, and locations of service drops for the BHS related Motor Control Panels (MCPs).
- 3.1.8. The Designer will coordinate IT requirements for connectivity of all TSA supplied equipment to ensure HAS IT Standards are achieved.

3.2. Testing

- 3.2.1. The BHSC will ensure that the BHS, including the CBIS complies with HAS testing requirements and the latest version of the TSA PGDS.

- 3.2.2.** The BHSC static testing preparation shall include opened electronic components to verify proper wiring terminations and labels, opened and locked-out/tagged-out MCPs, opened High-Speed Diverters (HSDs) and other such preparations that provide full access to the system and its components. The BHSC dynamic testing preparation shall include a fully operational system that is clean and free from construction and obstructions and other related activities.
- 3.2.3.** The BHS, including the mechanical, electronic and software control, will be fully functional and free from obvious failures and other conditions that distract from a successful completion of the tests required in the latest version of the TSA PGDS. Catwalk, handrails and ladders will also be installed prior to dynamic testing.
- 3.2.4.** BHS/EDS integration testing preparation shall meet all the requirements as defined in the Specification, other related documents and review meetings for TSA Integrated Site Acceptance Testing (ISAT), TSA Test Readiness Review (TRR), TSA Site Specific Test Plan (SSTP) and any other HAS required testing including HAS commissioning required testing.

3.3. Training, Operations, and Manual

- 3.3.1.** The Operation and Maintenance (O&M) Manual documentation provides the HAS O&M staff with all information required to safely, successfully and properly use and maintain the baggage handling equipment and system. The documentation must include separate, comprehensive documents with information directed toward specific tasks and skill-sets. All topics within the project shall be included. The documentation must be transmitted in an Adobe Acrobat® PDF that includes a record of revisions, details of changes made to the documentation including dates of the changes, and that allows the user to navigate all information in an orderly and logical manner.
- 3.3.2.** The operational staff includes TSA, curbside, ticket counter and baggage handling personnel. The information generated for this group must also supply management and ownership general information regarding the layout and safe operation of the system. How the system was designed and intended for use, including all load and unload conveyors, as well as failure modes of operation must be incorporated within the contents of the operation information. This should not be complicated or overly detailed information.
- 3.3.3.** It should be concisely written and short enough to introduce personnel to the system in a quick, to-the-point and efficient manner. Efforts should be made to avoid repeating information.
- 3.3.4.** The O&M Manual will contain detailed information on procedures to program and configure various special control devices used in the BHS. This will include all information personnel needs to replace and reconfigure these devices.
- 3.3.5.** The O&M Manual will contain detailed information on a recommended program of when to conduct preventive maintenance procedures.
- 3.3.6.** The O&M Manual will contain detailed information supplied by the manufacturers for all the purchased assemblies and major components (parts) used in the BHS.
- 3.3.7.** All manufacturer's literature will include information for proper servicing the assembly, proper operation of the assembly, procedures for programming and calibrating the assembly, and all required information for ordering the assembly.

22 - COMMUNICATIONS AND IT



22 - Communications and IT

Part 1 – General

1.1. Overall

- 1.1.1.** The communications and information technology (IT) Standards will be managed and updated regularly by the Houston Airport System (HAS) IT department.
- 1.1.2.** This Section will not follow the same formatting as others in the Design Standards Manual.
- 1.1.3.** Please use the HAS IT department's most up-to-date IT Design Standards found on their website.

23 – ELECTRICAL



23 - Electrical

Basic Electrical Requirements

Part 1 – General

1.1. Overview

1.1.1. These Design Standards have been developed and adopted by the Houston Airport System (HAS) to assure superior quality and workmanship resulting in projects that have long life expectancy, are less vulnerable to damage and are easily maintained. It is not the intention of these Design Standards to make project design and installation unreasonably difficult or costly or to supersede sound engineering judgement. If a consultant or tenant has an alternate, code approved method that they would like to be considered, they may contact the HAS Project Manager. Communication must be in writing, and the request will be reviewed on a case-by-case basis. Approval of an alternate request does not constitute a waiver of these standards.

1.2. Service and Distribution

1.2.1. General

- 1.2.1.1. Dual circuit configuration will be maintained throughout all new design and construction projects and planned facility renovations or modernization projects.
- 1.2.1.2. All substations and main distribution will be dual-fed, main-tie-tie-main arrangements. Additionally, all powered equipment that is mechanically redundant, will have one set of equipment fed from power side “A” and the other mechanical equipment fed from power side “B.” This is where there is critical equipment that is not redundant. It would have a dedicated automatic transfer switch fed by “A” and “B” circuits.
- 1.2.1.3. All distribution equipment will have a minimum of 25 percent spare capacity for future additions based on initial maximum design load conditions.

1.3. HAS Electrical Permitting Requirements

1.3.1. General

- 1.3.1.1. Tenants, contractors and/or consultants will comply with all Plan Review requirements, including all coordination with the HAS Building Standards Group (BSG), COH Permitting, Fire Marshall, etc.
- 1.3.1.2. Contractors will comply with the latest City of Houston (COH) Electrical Ordinance, National Electrical Code (NEC), and other applicable codes and standards.
- 1.3.1.3. Contractors will secure all required permits prior to the commencement of any electrical work.
- 1.3.1.4. Contractors will employ only personnel with a Texas State license and COH electrical contractor license.
- 1.3.1.5. Electrical contractors will ensure that electricians always carry their Texas Department of Licensing and Regulation (TDLR) license while performing work. For verification purposes, electricians must always have their state-issued photo identification on their person as well.

- 1.3.1.6. Electrical contractors will have a minimum of one Journeyman Electrician on-site when performing electrical work. In this instance, the term “on-site” means within a work area that is readily monitored by the Journeyman.
- 1.3.1.7. All contractors, or HAS employees, will abide by all Occupational Safety and Health Administration (OSHA) and National Fire Protection Association (NFPA) safety practices. All contractors or HAS employees, will comply with HAS procedure, OSP SOP VII-145-301 Lock- Out-Tag-Out (LOTO), and accurately maintain records when securing electrical equipment for safety. Records must be kept on file when performing LOTO procedures.
- 1.3.1.8. There will be a copy of the most current Electrical Code on site always during construction.
- 1.3.1.9. A copy of the permitted construction plans will be on site always.
- 1.3.1.10. There will be a required MCB for all tenant space main panels and must be accessible to the tenant at all times.
- 1.3.1.11. The use of stranded No. 12 and 10 wire will be permitted for all applications.
- 1.3.1.12. Before any new service is energized in a new tenant space, there will be a required inspection of the new service and it must have permanent labels installed on all equipment, as required per code.
- 1.3.1.13. Any request for changes in conduit sizes or the use of MC cable must be submitted in writing (E-mail) to BSG electrical inspectors for approval.
- 1.3.1.14. NFPA 70-E will be required before energizing any electrical service.
- 1.3.1.15. All electricians will be required to have a current copy of their state license on their person at all times with additional copy of a photo ID.
- 1.3.1.16. There will be a lockout on the circuit breaker for the fire alarm system and the emergency lights/exit lights.
- 1.3.1.17. The requirement for service release to CenterPoint will need the following Information:
 - Physical address, account number, ESID number and BSG permit number.
 - Note: Physical address must be on meter can and be phenolic label.
 - Electrical Inspectors for HAS/BSG: Contact HAS PM for contacts.

1.3.2. HAS Plan Review Requirements

1.3.2.1. Power drawing(s) will include:

- One-line diagram of a power distribution system
- One-line diagram of emergency system(s)
- Panel schedule(s)
- Load analysis
- There will be voltage drop calculations submitted with all plans for review.
- Power outlets
- Outlet locations
- Circuit number and panel designation
- Conduit and wire size for each circuit
- The note, Type AC (BX) and MC cable is prohibited on every drawing.
- Upon submittal of plans, the grounding, bonding, and lightning protection will be submitted on separate sheets of the electrical plans.
- Electrical room number

1.3.2.2. Lighting drawing(s) will include:

- Emergency lighting location and circuiting
- Exit lighting location and circuiting
- Fixture schedule
- Lighting fixture layout
- Lighting fixture location and type(s)
- Circuit number and panel designation
- Switching
- Each drawing will include the note: "Type AC (BX) and MC cable is prohibited"
- All emergency lighting, exit lighting indoors and outdoors, all exit doors, mechanical, electrical, IDF, MDF rooms shall have battery back-up on emergency lighting and exit lighting.

1.4. General Requirements

1.4.1. Equipment Safety: All electrical materials and equipment will be new, listed by Underwriter's Laboratories, Inc. (UL) and bearing their label, or marked with their name. Custom made equipment must have complete test data, submitted by the manufacturer, attesting to its safety.

1.4.2. Codes and Regulations: Designing, manufacturing, testing, and the method of installation for all apparatus and materials, furnished under the requirements of these Standards, will conform to the latest publications or standard rules of the following:

- Institute of Electrical and Electronic Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- UL
- NFPA
- American Society for Testing and Materials (ASTM)
- American National Standards Institute (ANSI)
- NEC, with COH Amendments
- Insulated Cable Engineers Association (ICEA)
- InterNational Electrical Testing Association (NETA)

1.4.3. Cutting and Patching:

1.4.3.1. Contractor must obtain written permission from HAS before core drilling or cutting any structural member. The exact method and location of conduit penetrations and/ or openings in concrete walls, floors, or ceilings will be approved by HAS.

1.4.3.2. Contractor must use care in piercing and waterproofing. After the piercing has been done and the waterproofing set in place, the Contractor will seal the openings and make the pierced area watertight.

1.4.3.3. The Contractor must seal all openings to meet the fire rating of the particular wall, floor, or ceiling. The Contractor must also seal penetrations of all smoke walls using approved methods and materials.

1.4.4. Miscellaneous:

1.4.4.1. Light-emitting diode (LED) control lights will be used in all switchgear, switchboards, motor control

centers, and similar equipment.

- 1.4.4.2. Outdoor equipment enclosures will be NEMA 4. Outdoor equipment/devices will have an IP65 rating, as applicable.
- 1.4.4.3. Total voltage drop will be less than 5 percent. Limit feeder drop to less than 2 percent and branch circuit drop to less than 3 percent. Branch circuit drop will be based on the furthest outlet operating at design demand. For circuits with multiple outlets or load connections along the length of the circuit, drop will be based on expected diversity of demands. Branch circuits rated 20 amp over 75 circuit feet to furthest outlet operating at 120 volts will be No. 10 American Wire Gauge (AWG), and this will be the largest wire size allowed (no upsizing and tapping will be allowed, therefore planning will consider location of panelboards to preclude such circuit conditions). Branch circuits rated 20 amp over 175 circuit feet to the furthest outlet operating at 277 volts will be No.10 AWG, and this will be the largest wire size allowed. Circuits in excess of the above lengths will not be permitted. It is incumbent on the Designer to ensure that the serving panelboard locations facilitate keeping branch circuit lengths within the given circuit feet.
- 1.4.4.4. Unless directed otherwise by HAS, the default branch circuit wiring design for connecting free-standing office furniture partitions shall be “eight-wire,” with one “dirty” multi-wire circuit and a single 120 volt/20 amp “clean” circuit. The multi-wire will consist of three-Hot legs/ one-Neutral (one size larger than Hot legs), with a grounding conductor. This circuit will be served from a three-pole circuit breaker in the serving panelboard (or three-adjacent poles with handle tie devices). The “clean” circuit will be from a panelboard that is dedicated only to computer equipment within the offices. Up to eight workstations may be served from the “dirty” circuit and up to five from the “clean” circuit. The Designer will coordinate with the furniture vendor to assure total NEC calculated outlets do not exceed the above limits and are inclusive of at least 20 percent spare capacity. Designer will provide disconnecting means conforming to NEC for multi-wire circuits serving furniture partition outlets.
- 1.4.4.5. All direct buried counterpoise group wire used at HAS facilities will be No. 6 AWG, stranded bare copper wire conforming to ASTM B-3 and B-8.
- 1.4.4.6. All free-standing equipment including, but not limited to, distribution panels, transformer, switchboards, switchgear, and Uninterruptible Power Supplies (UPS) will be installed on 6-inch-high housekeeping pads. Pads will be hand finished smooth and will have chamfered edges.
- 1.4.4.7. New electrical rooms and closets will be above the flood plain level landside and airside of the buildings. No service or distribution equipment will be located below flood plain level.
- 1.4.4.8. All substations located indoors will be “drip proof” enclosure types, and all conduit entries on the top of the enclosures will utilize “Meyers” hubs (or HAS-approved equivalent). Bus duct entries will either be on the ends of the switchgear or on top. If on top, bus duct will be terminated on an auxiliary section that does not contain any circuit breaker or control devices.
- 1.4.4.9. Primary and secondary service entrance conduits will be concrete encased, unless specific project requirements dictate alternate installation methods. The primary duct bank will be marked with red dye. Duct banks that run below any building will be rerouted to minimize the extent that it runs beneath the slab. The duct bank will run at a right angle toward the building lines and will be fully steel reinforced and concrete encased. Conduits will drain away from any stub-ups into the buildings. Stub-ups will be rigid galvanized steel and slab penetrations will be designed to allow full concrete filling between conduits to provide water stop. Conduits will also have water seals applied where conductors exit the conduit to terminate within equipment.
- 1.4.4.10. Notify CPE if access to their manholes, vaults, or equipment is required. This will be coordinated a minimum of 30 working days in advance, unless extenuating circumstances make this impracticable.
- 1.4.4.11. Control power transformers for automatic flush plumbing fixtures, will be located above accessible ceilings outside of restrooms. Any control wiring that is not installed within a fully accessible plumbing chase, will be run through either conduits or a conduit to outlet boxes.
- 1.4.4.12. Fuses will not be allowed within new electrical or control systems, unless they are integral to an approved manufacturer’s equipment. Exceptions may be considered on a case-by-case basis and approved with written consent from HAS. In-line fuses for luminaires is a requirement; refer to other

Sections of this Standard for other exceptions.

1.5. Location and Protection of Utilities and Work Area Notices

- 1.5.1.** Contractor will be responsible for contacting the utility coordinating and locating companies, securing all required Work Area Notices (WAN) and the HAS inspector assigned to the project prior to any construction and/or excavation on any HAS facility. The HAS Project Manager will assist the contractor in coordinating with HAS maintenance through the job control process to locate and identify HAS-owned utilities. Requests to HAS maintenance should will be made at least 48 hours prior to digging, and be coordinated through the HAS eWan process. Location of non-HAS owned utilities will be coordinated with HAS via the HAS Project Manager.
- 1.5.2.** The Contractor is responsible to take any and all precautions necessary to avoid damaging any utilities and to maintain personnel safety. If a Contractor damages an identified utility or does damage because of their failure to have the utility located, it will be the Contractor's responsibility to make appropriate repairs at their expense. Repairs will be made in conformance with this electrical standard, as applicable. Any repairs that must be made by HAS personnel will be charged back to the Contractor. These charges will include penalties adequate to discourage irresponsible work regarding utilities at HAS facilities.

1.5.3. Work Area Notification (WAN)

- 1.5.3.1.** A WAN following the HAS Electronic (or eWan) system requirements will be used for all occasions when performing work in an HAS electrical room and will include the following at a minimum:
- Date WAN was issued
 - Each contractor's name performing the work and contact numbers
 - Involved parties overseeing the work and contact numbers
 - Primary contact name and number of responsible person in charge of work
 - E-mail addresses of all Electrical Systems Division Manager and Superintendents
- 1.5.3.1.1.** Contact HAS for appropriate and current WAN form/template
- 1.5.3.1.2.** Additional information may include location, description, date of request, time of construction, comments, and impacts to the site and surrounding area, Security Identification Display Area (SIDA) affected, and traffic control plans, etc.
- 1.5.3.1.3.** A copy of the WAN and the BSG permit must be posted on the front entry door before work may commence.

1.6. Power Shutdown Procedures

- 1.6.1.** The Contractor's construction schedule will indicate dates of proposed electrical power shutdowns required to perform the installation. The Contractor will notify HAS a minimum of 30 days prior to each shutdown. All shutdown coordination meetings will be arranged by the Contractor.
- 1.6.2.** Any power shutdown will be performed only after written approval by HAS.
- 1.6.3.** Power shutdowns will occur between the hours of 12:00 am and 4:00 am.
- 1.6.4.** Only one switchboard will be shut down at any one time and shutdowns will be scheduled a minimum of three days apart.
- 1.6.5.** No interruptions to airport operations will be allowed during periods deemed by HAS as Holiday Construction Restriction Periods. These periods are typically from the Friday before the week of Thanksgiving Holiday to the Monday following the Thanksgiving Holiday (nine calendar days), and the Friday before the week of the Christmas Holiday to the Monday following New Year's Day (16 calendar

days).

- 1.6.6.** The Contractor must verify the Holiday Construction Restriction periods with HAS prior to preparing the construction schedule.

1.7. Temporary Power

- 1.7.1.** Contractors will be responsible for, at their own expense, the installation of all temporary electrical utilities.

- 1.7.2.** Unless otherwise directed by the IAH Engineer or the Electrical Superintendent, the Contractor will remove all vestiges of temporary construction utilities upon completion of the project.

1.7.3. Equipment Accessibility:

- 1.7.3.1.** All new facilities will be designed such that major equipment components can be transported into and out of the facility without having to demolish any permanent walls. The Designer will verify and indicate equipment installation and maintenance access on the drawings during design development. The equipment component may be, for example, a shipping split in the case of switchgear, or the core of a transformer. For indoor diesel generators and other large equipment, the ability to remove equipment via removable exterior wall panels to a truck loading area is mandatory. Equipment located on roofs will be accessible and means will be permanently provided to facilitate lowering and lifting major components for replacement.

- 1.7.3.2.** The architectural design of new facilities will consider possible planned or potential changes to the facility that may restrict access to equipment or to such components as bus ducts. A design must be provided that mitigates future conflicts.

1.8. Electrical Testing

- 1.8.1.** In accordance with ANSI/NETA ATS-2017 (or the most current version), all equipment, conductors, and systems included within the HAS Electrical Standards, and those that may be in addition to the Electrical Standards current content, due to specific project design, will be tested. Such testing will apply to field testing and as applicable, to factory testing.

- 1.8.2.** All testing will be witnessed by BSG Electrical Inspectors and HAS Commissioning Authority (CxA), unless the electrical inspectors elects not to witness any or all particular tests. The Contractor shall provide required advance notice and detailed testing schedule.

- 1.8.3.** All testing data and records will be certified.

Part 2 – Products

2.1. Manufacturers

- 2.1.1.** The Basis of Design for electrical distribution equipment, except as otherwise noted, will be Schneider Electric (Square D) or an HAS pre-approved equivalent.

- 2.1.2.** The Basis of Design for Uninterruptible Power Supplies (UPS) will be Eaton. No other manufacturer is approved for use due to existing installations and Airport-wide service contract.

- 2.1.3.** The Basis of Design for low-voltage (600 volt class) automatic transfer switches will be Russelectric, or an HAS pre-approved equivalent.

- 2.1.4.** For other electrical components and materials, refer to other Sections of this Standard as applicable. Where no manufacturer names are stipulated, it is expected that proposed manufacturers will be industry leaders in quality and performance and fully conform to the technical, operations, and maintenance requirements. Proposed manufacturers must have local maintenance and service technical support.

Part 3 – Execution

3.1. Installation

- 3.1.1.** Upon completion of a project, the Contractor will provide an updated one-line diagram of the distribution system.
- 3.1.2.** For large projects (more than two panels and one transformer) a copy of the one- line diagram will be framed, covered with a transparent plastic (plexi-glass) cover, and mounted where approved by the IAH.
- 3.1.3.** Engineer or Electrical Superintendent. This location may be a convenient wall or the back of the electrical room door.
- 3.1.4.** For small projects, a suitable protected one-line diagram may be mounted on the cover of the distribution panel.

Selective Demolition

Part 1 – General

1.1 Common Work Results

- 1.1.1.** Selective demolition will be performed based on engineered and sealed drawings, unless otherwise approved by HAS.
- 1.1.2.** Field investigations will be done to trace and verify outlets and loads served by any circuit to be affected or that traverses an area of work thereby exposed to demolition activity that might cause an interruption to the circuit. The results of these investigations will be provided to the Designer for use in preparing drawings for the demolition activities. As part of field investigations, the electrical contractor will provide data on loads (lighting fixtures, outlets, motors, and other equipment) that will continue to be connected to the circuit within or outside the work area. This will enable the Designer to verify that the new work will not overload a circuit that is to continue in service.
- 1.1.3.** Design and demolition work will provide any temporary or permanently installed circuits to enable continuation of service to areas outside the work area. These will be in place, fully tested, and inspected prior to proceeding with any phase of demolition work.
- 1.1.4.** Within demolition areas, do not abandon any feeder/branch circuits, conduit, and conductors. Unless specifically agreed to in writing by the HAS Electrical Superintendent, such circuits or empty conduits may be abandoned if it is thought these may serve useful purpose in the future. Demolition and removal of such circuits will extend outside the work area to the first available junction box to remain in service to continue serving loads outside the work area. If no such box exists, the entire circuit (homerun) will be demolished back to the panelboard or other serving equipment.
- 1.1.5.** Similarly, demolish and remove all low voltage, signal, security, and communications cables completely. No such cables will be touched without verifying, prior to demolition, that the cables are not needed to maintain continuity to points outside the work area.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Medium-Voltage Cables

Part 1 - General (Not Used) Part 2 – Products

2.1. Manufacturers

2.1.1. Medium voltage cables will be manufactured by the following companies unless otherwise approved by HAS:

- The Okonite Company
- Pirelli Cable Corporation
- Rome Cable Corporation

2.2. Single Conductors

2.2.1. Voltage: 15 kV (applicable to IAH)

2.2.2. Insulation Level: 133 percent of operating voltage

2.2.3. Cable Continuous Operating Temperature Rating: MV 105

2.2.4. Configuration: Single conductor

2.2.5. Conductor Material: Copper

2.2.6. Conductor Construction: Compact stranded

2.2.7. Conductor Shield: Ethylene propylene (EP) or ethylene propylene rubber (EPR)

2.2.8. Non-Armor Jacket: Polyvinyl chloride (PVC) with red extruded identification stripe

2.2.9. Phase Color Identification: Refer to Low- Voltage Electrical Power Conductors and Cables Section of this Standard.

Part 3 – Execution

3.1. Fireproofing

3.1.1. Apply fireproofing tape to cables when installed in manholes, cable rooms, pull boxes, or other enclosures.

3.1.2. Smooth out irregularities at splices or other locations with insulation putty before applying fireproofing

tape.

- 3.1.3. Apply fireproofing tape tightly around cables spirally, in half-lapped wrapping, or in butt jointed wrapping with second wrapping covering joints first.
- 3.1.4. Extend fireproofing 1 inch into conduit or duct.
- 3.1.5. Install tape with coated side toward cable.
- 3.1.6. Install random wrappings of plastic tape around fireproofing tape to prevent unraveling.
- 3.1.7. Install fireproofing to withstand a 200 amp arc for 30 seconds.

3.2. Separable Insulated Connectors

- 3.2.1. **Description:** Provide modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- 3.2.2. **Terminations at Distribution Points:** Provide modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
 - 3.2.2.1. **Load-Break Cable Terminators:** Provide elbow-type units with 200 amp load make/ break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
 - 3.2.2.2. **Dead-Break Cable Terminators:** Provide elbow-type unit with 600 amp continuous- current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
 - 3.2.2.3. **Dead-Front Terminal Junctions:** Provide modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two, three, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware. Delete drain wire as noted below, if not required.
 - 3.2.2.4. **Protective Cap:** Provide insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 3.2.2.5. **Portable Feed-Through Accessory:** Provide two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3.2.2.6. **Grounding Kit:** Provide jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - 3.2.2.7. **Standoff Insulator:** Provide portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
 - 3.2.2.8. **Test-Point Fault Indicators:** Provide applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
 - 3.2.2.9. **Tool Set:** Provide shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.
- 3.2.3. **Fault Indicators**
 - 3.2.3.1. Provide automatic reset, in-rush restraint type fault indicators at all splices and at all terminations. Provide all mounting kits and adapters as required. Manufacturer to recommend correct trip ratings at each location to be used. Manual reset types are prohibited. Provide a display that a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and will be recommended by manufacturer for installation conditions.

- 3.2.3.2. **Mounting:** Arranged to clamp to cable sheath on cable terminations or test points on elbow connectors.
- 3.2.3.3. Provide Cooper Power Systems, or approved equal, S.T.A.R. (capacitive test point) fault indicator.
- 3.2.3.4. Provide corrosion resistant, clamp-on current type reset units on terminations without capacitive test points. Cooper Power Systems, or equal, CRR3PD fault indicator with three-phase remote display on all solid terminations.
- 3.2.3.5. Provide one test point tool suitable for each type of indicator.
- 3.2.3.6.

Low-Voltage Electrical Power Conductors and Cables

Part 1 - General (Not Used) Part 2 – Products

2.1. Manufacturers

- 2.1.1. Low-Voltage electrical power conductors and cables will be manufactured by the following companies unless otherwise approved by HAS:
 - General Cable Co.
 - Southwire Co.
 - Rome Cable Co.

2.2. Single Conductor Insulated Wire

2.2.1. Description:

- **Conductor:** Copper
- **Insulation Voltage Rating:** 600 volts
- **Insulation Temperature Rating:** 167°F
- **Insulation Material:** Thermoplastic

2.3. Function and Application

- 2.3.1. Types AC (BX) and MC cables are prohibited, unless given written permission by HAS Building Services Group's Electrical Superintendent, except for UL listed light fixture whips, not exceeding six feet in length, terminating at a junction box. Daisy chaining from fixture to fixture or outlet to outlet is prohibited
- 2.3.2. All conductors will be copper. Aluminum is permitted only for aerial installations from pole to pole, pole to building, or building to building applications.
- 2.3.3. Minimum wire size for branch circuits will be No. 12 AWG copper.
- 2.3.4. No. 14 or 16 AWG copper may be used for control circuits and only with proper OCP.
- 2.3.5. Stranded wire sizes No. 10 and 12 copper may be used provided that:
 - Circuits are connected to wiring devices that utilize clamp type terminations rather than binder head screw connections

- Terminations are made using spade type lugs for binder head screw connections
- Terminations are spliced to solid by means of butt splice for attachment to binder head screw connections.

2.3.6. Stranded conductors will be used for all motor and control circuit wiring.

2.3.7. Homerun neutral conductors of any multi-wire 120 volt, 20 amp circuit feeding outlets for computers, or any outlet in proximity to an IT outlet, will be upsized to one wire size larger than the phase conductors.

2.3.8. Conductor color coding will be consistent along the entire length of a circuit. Color coding will be as follows:

Exhibit 4-1: Wire Color Chart

Conductor	120/208V	277/480V	12.5kV
Phase A	Black	Brown	Black
Phase B	Red	Purple	Red
Phase C	Blue	Yellow	Blue
Neutral	White	Grey	
Equipment Ground	Green	Green	Green
Isolated Ground	Green/Yellow Stripe	Green/Yellow Stripe	

Part 3 – Execution

3.1. Installation

3.1.1. All wiring will be installed in conduit and be adequately supported for raceway and equipment meet the most recent NEC requirements. Open wiring is prohibited.

3.1.2. Direct burial cable is prohibited.

3.2. Special Techniques - Wiring Connections

3.2.1. Clean conductor surfaces before installing lugs and connectors.

3.2.2. Make splices, taps, and terminations carry full capacity of conductors with no perceptible temperature rise.

3.2.3. Tape uninsulated conductors and connectors with electrical tape to 150 percent of insulation rating of conductor.

3.2.4. Install split bolt connectors for copper conductor splices and taps, 6 AWG and larger.

3.2.5. Install solderless pressure connectors with insulating covers for copper conductor splice and taps, 8 AWG and smaller.

3.2.6. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

3.2.7.

Ground and Bonding for Electrical Systems

Part 1 – General

1.1. Common Work Results

- 1.1.1. **Grounding System Resistance:** 5 ohms maximum.
- 1.1.2. Refer to Section 3 of this Standard for IT grounding.

Part 2 – Products

2.1. Information

- 2.1.1. Ground rods will be $\frac{3}{4}$ inch by 10 feet (minimum), and will be stainless-steel.

Part 3 – Execution

3.1. Installation

- 3.1.1. Where an equipment grounding conductor is required by the NEC to supplement the grounding capacity of flexible conduit, the conductor must be installed outside the conduit and attached at each end of the flexible conduit with UL listed bonding fittings.

Hangars and Supports for Electrical Systems

Part 1 – General

1.1. Common Work Results

- 1.1.1. Product selection will fully consider the application user and the environment of the installation location. The product will have a serviceable life expectancy at least equal to the expected life of the facility.
- 1.1.2. Protection of materials and support systems from the effects of corrosion will be fully considered in selection/specifications. This will include being able to disassemble by unscrewing bolts, nuts, and other devices absent of corrosion that might otherwise inhibit disassembly.

Part 2 - Products (Not Used)

Part 3 - Execution

3.1. Installation

- 3.1.1.** Installers will ensure adequate support for raceways and equipment.
- 3.1.2.** Set all equipment level and plumb.
- 3.1.3.** Prevent vibration or swaying.
- 3.1.4.** Provide for expansion, contraction and deflection using UL listed expansion fittings and proper bonding dtraps.
- 3.1.5.** Coordinate anchor and guide points to structure with other trades.
- 3.1.6.** Equipment will be installed on vibration isolators, rigid and secure, plumb and level, and in alignment with related and adjoining work.
- 3.1.7.** Provide seismic supports where required.
- 3.1.8.** Supports of wire, rope, wood, chain, perforated strap, or any other makeshift device will not be permitted.
- 3.1.9.** Installation and spacing of supports will be in accordance with applicable codes and good design practice.
- 3.1.10.** Powder driven studs into concrete are not acceptable.
- 3.1.11.** Electrical equipment will be installed to provide the maximum headroom possible.
- 3.1.12.** All conduit will be installed parallel and/or at right angles to beams, walls, etc.
- 3.1.13.** Support and secure conduit at spacing in accordance with code requirements by means of galvanized pipe straps, conduit clips, ring bolt type hangers, or by other proper manufactured devices.
- 3.1.14.** Conduits passing through floors and walls will be sleeved or protected by resilient material. Sleeves and non-combustible resilient annular packing will be used where conduit passes through fire separations, or as required by local code enforcement.

Raceways and Boxes for Electrical Systems

Part 1 - General

1.1. Common Work Results

- 1.1.1.** All wiring of any system, type, and class will be run in metallic conduit. No open wiring of any type is allowed.
- 1.1.2.** All junction and pull boxes will be accessible and reachable by means of ladder or a man- lifting apparatus, without having to open more than an access panel or one ceiling tile.
- 1.1.3.** Any conduit for any system crossing a building expansion joint, will utilize listed expansion fittings and be properly supported on both sides of the joint with proper UL Listed bonding strap and be clamped on each side of expansion fitting.

Part 2 - Products

2.1. Information

- 2.1.1.** Minimum trade size of conduit will be ¾ inch.
- 2.1.2.** In locations where conduits are subject to severe physical damage (not limited to, but inclusive of warehouses, landing docks, or baggage handling areas where vehicular traffic is a potential source of

damage), conduit will be rigid galvanized steel to a minimum height of 8 feet above finish floor or finish grade. Additionally, such conduit locations will be mechanically protected by bollards or galvanized steel guards. Bollards, bollard foundations, and structural guards will be designed and specified appropriately to the exposure and potential impact force.

- 2.1.3.** Flexible metallic conduit (“Greenfield”) will be permitted only for use as “fixture whips” and for connections to fractional horsepower motors. The minimum allowable size will be ½ inch. The only exception is for individual fixture whips.
- 2.1.4.** Liquid tight flexible metallic conduit will be used for transformer or motor connections, where flexibility is required due to installation applications. All flexible metallic conduit outdoors or anywhere subject to water (or other fluid) leakage, will also be liquid tight.
- 2.1.5.** The minimum length of flexible metallic conduit (or liquid tight) for final connection to vibrating equipment will be 4 feet. The maximum length for any connection will be 6 feet.
- 2.1.6.** Where NEC requires an equipment grounding conductor to supplement the grounding capacity of flexible conduit, it must be installed outside the conduit and attached at each end of the flexible conduit with UL listed bonding fittings.

2.2. Function / Application

- 2.2.1.** The maximum total angular bends in any run of conduit that is not underground will be 270 degrees.
- 2.2.2.** Pull boxes for indoor work will be located no more than 90 feet between boxes.
- 2.2.3.** Pull boxes and hand holes will be installed at a maximum of 150 feet apart for indoor feeder installations, and each change in direction of 60 degrees or more will have a pull box or a hand hole at the directional change or within 5 feet of that location.
- 2.2.4.** Boxes will be supported independently of the conduit and to the structure of the building.
- 2.2.5.** Device boxes will be a minimum of 4 inches by 4 inches by 1-1/2 inches and use a device ring.
- 2.2.6.** Above floor service fittings and poke-through devices are not permitted without express written consent of HAS during the design stage.
- 2.2.7.** All conduits will be Electrical Metallic Tubing (EMT) for building interiors, unless otherwise stated herein.
- 2.2.8.** Rigid Galvanized Steel (RGS) will be permitted for exterior applications.
- 2.2.9.** Meyers hubs, or a HAS-approved equivalent, will be used for all connections to any outdoor panelboards or other distribution equipment. It will also be used for branch circuit connections to any outdoor power consuming equipment and for termination of control and communications conduits on apparatus or control panels.
- 2.2.10.** Meyers hubs, or a HAS-approved equivalent, will be used for all connections to switchgear, switchboards, or distribution panelboards rated 800 amps, or above. They will also be used within indoor locations where subject to any leaking from any piping passing in proximity to the installation, or release of fire protection sprinkler heads.
- 2.2.11.** Avoid moisture traps in any areas subject to condensation within conduit and install a junction box with drain fittings at low points in the conduit system.
- 2.2.12.** All rigid and intermediate metallic conduit couplings will be a threaded type. No “HUB” fittings are prohibited.

Part 3 – Execution

3.1. Installation

3.1.1. All conduit will be concealed above the ceiling, under the floor, or in the walls, to the maximum extent possible. Exposed conduit will not be installed on exterior building surfaces or in public areas.

3.1.2.

Underground Ducts and Raceways for Electrical Systems

Part 1 - General

1.1. Communication and Electrical Manholes, Junction Boxes, and Pull Boxes

1.1.1. These structures will be located outside the runway and taxiway safety areas, as defined in Advisory Circular (AC) 150/5300-13, where HAS Maintenance personnel can service them without closing runways or taxiways.

1.1.2. Structures will be sufficiently raised above the surrounding grade to prevent ponding water on the structure, the top cover will be sloped to drain. A concrete apron will be constructed around all electrical manholes located in turfed areas.

1.1.3. Attention will be given to storm water drainage plans to prevent placement of electrical structures in areas channeled for drainage. These structures will have all joints and openings completely sealed and vermin-proof, with secure covers with bolts.

1.1.4. Structures, covers, and frames in the runway and taxiway safety areas will be heavy duty. They will be designed for aircraft at 250 pounds per square inch (psi) tire pressures and wheel loads of at least 100,000 pounds.

1.1.5. Homerun manholes and pull boxes will be located at a maximum spacing of 600 feet on work results.

Part 2 - Products

2.1. Information

2.1.1. Schedule 40 or 80 PVC conduit will be used for underground feeders and branch circuits, as appropriate for the design conditions, governing standards, and/or best practices.

Part 3 - Execution

3.1. Installation

3.1.1. Hazard warning tape will be installed 6 inches below grade, directly above underground conduits for installations when the trench is back-filled.

3.1.2. The section of vertical conduit from 6 inches below grade will be rigid galvanized conduit. A coating of

asphalt or PVC will be applied from 6 inches below grade to 3 inches above finish grade.

- 3.1.3.** The conduit sizes for all underground branch circuits will be increased by one trade size for NEC required sizes of 1 inch and 1-1/4 inches (i.e., a code-required 1-inch conduit would be increased to 1-1/4 inch).
- 3.1.4.** Pull boxes and hand holes will be installed at a maximum of 450 feet apart for outdoor feeder installations. Each change in direction of 60 degrees or more will have a pull box or hand hole at the directional change or within 5 feet of that location.
- 3.1.5.** Pull boxes and hand holes will be installed at a maximum of 90 feet apart for outdoor branch circuits.

Identification for Electrical Systems

Part 1 - General

1.1. Common Work Results

- 1.1.1.** An airport-wide equipment numbering nomenclature will be established so that all electrical equipment and circuits will be uniquely identified and labeled.
- 1.1.2.** Equipment labels will be engraved on melamine plastic laminate, minimum 1/8-inch thick, and punched for mechanical fasteners. Equipment labels for exterior equipment will be reverse engraved melamine plastic laminate, rated for exterior use, clear in color, a minimum of 1/8-inch thick and applied using double stick tape designed for exterior applications.
- 1.1.3. Lettering Size:**
 - Minimum ¼ inch (6 millimeters) high lettering for name of unit where viewing distance is less than 24 inches (600 millimeters)
 - ½ inch (12 millimeters) high for distances up to 6 feet (2 meters)
 - Use proportionately larger lettering for greater distances
 - Provide secondary lettering of 2/3 inch to ¾ inch of size of the principal lettering
- 1.1.4.** Color coding will be as follows (current airport standards):
 - **Normal Power:** White letters on black face
 - **Emergency/Standby Power:** White letters on red face
 - **UPS Power:** White letters on orange face
- 1.1.5.** Provide equipment labels for each unit of the following:
 - Switchgear and switchboards
 - Panelboards, electrical cabinets, and enclosures
 - Bus ducts
 - Access panel/doors to electrical facilities
 - Motor starters, contactors, and disconnects
 - Automatic transfer switches
 - Transformers
 - UPS systems equipment

- Emergency/standby generator system equipment
- Lighting control panels
- Fire detection and alarm systems equipment
- Meters for tenants

- 1.1.6.** In addition to equipment names, labels will identify voltage and phase. All controls, function switches, etc., will be clearly labeled on all equipment panels. Nameplates for circuit breakers and switches will indicate source I.D., feeder number, and load I.D. Nameplates on switch gear, switch board, distribution panels, and lighting panel equipment will indicate the source of power, room number, and circuit number.
- 1.1.7.** Panelboard and circuit numbers will be identified on receptacle faceplates and light switch faceplates. They will be engraved or etched designations with 3/16-inch high block letters filled with black enamel for normal power, red enamel for emergency/ standby power, or orange enamel for UPS power.

1.2. Nameplates on Equipment

- 1.2.1. Engraved Plastic Nameplates and Signs:** Engraving stock and melamine plastic laminate will be a minimum of 1/16-inch (1.6 millimeters) thick, for signs up to 20 square inches (129 square centimeters), and 1/8-inch (3.2 millimeters) thick for larger sizes. It can be punched or drilled for mechanical fasteners and text must be at 1/2-inch (13 millimeters) high lettering.

- 1.2.2.** Nameplates will adequately describe the function of the equipment involved.

1.2.2.1. Where nameplates are detailed on the drawings, inscription and size of letters will be as shown and the shop drawings submitted for approval.

1.2.2.2. Nameplates for panelboards and switchboards will include the panel designation, voltage, phase and wire.

1.2.2.3. The next item will be where it serves such as HAS, Concessions, or Airline panel etc.

1.2.2.4. In addition, describe where the panel is fed from. For example, Panel 1LA, 120/208V, 3PH, 4W HAS Panel fed from MS. And the electric room number from where it is being fed from.

- 1.2.3.** Nameplates will be secured to the front of equipment using stainless steel screws or rivets.

1.2.3.1. Custom metal master nameplates will be furnished and installed by the manufacturer on each distribution section, switchboard section, and motor control center. They will indicate the manufacturer's name, ampere rating, short-circuit rating (bus bracing), and date. Paper stickers are not acceptable.

1.2.3.1.1. Example:

- ABC Switchboard Co.
- Ampere rating: 5,000 amp
- Short circuit rating: 100 KAIC
- Date: 01/01/2011
- Panelboard

1.2.4. All conduits, busways, cable trays, and pull boxes will be identified with permanent black letters and numbers which indicate the source panel (feeder supply source), circuit numbers, and designated panel or load. For example, the label "PA-1,3,5 TO MG" for conduits, the letter height will be 1/3 the conduit size with 1/4-inch minimum height. For pull boxes and busways, the letter height will be 1/2-inch minimum height and not larger than 3/4-inch height.

1.2.5. The identifications for conduits, busways and cable trays will be placed in 50-foot intervals and within 10 feet of wall and floor penetrations, pull boxes, panels, distribution boards, switchboards, and electrical

equipment.

1.2.6. Spare conduits, pull boxes, busways, and abandoned raceways that are to remain as shown on the drawings, will be identified as described above in 1.2.4 and 1.2.5.

1.2.7. The permanent marking identifications on the raceways and pull boxes will be visible after the installations are made.

1.2.8. All receptacle and switch faceplates will be labeled with the source panel and circuit number.

1.2.8.1. The label will be black Arial font on white or clear tape, produced by a P-Touch or other label machine.

1.2.8.2.1. Underground Warning Tape

1.2.8.2.2. Description: Permanent, detectable, red colored, continuous printed, and polyethylene tape with suitable warning legend describing buried electrical lines. Tape will be minimum 6 inches wide by 4 millimeters thick. Other color codes include:

- Safety Red is electric and lighting conduit and cables
- Safety Yellow is gas, oil, steam, petroleum, or gaseous materials
- Safety Orange is telephone, alarm, or signal cables and conduit
- Safety Blue is potable water or irrigation
- Safety Green is sewer or drain lines

1.2.9. Manhole and Underground Pull Box Cover Label

1.2.9.1. All manhole and underground pull box covers will have the following cast-in or bead welded, and galvanized identification label permanently affixed to the exterior:

- “ELEC-LV” for electrical power circuits 600 volts or less
- “ELEC-HV” for electrical power circuits over 600 volts
- “COMM” for communications circuits

1.2.9.2. A custom three-digit number will be added to the cover. Contact the Engineer for number assignment.

1.2.9.3. The minimum letter height will be 1 inch.

1.2.9.4. **Trace Wire:** Magnetic detectable conductor, red colored plastic covering, imprinted with “Medium Voltage Cable” in large letters.

Part 2 - Products (Not Used) Part 3 - Execution (Not Used)

Power System Studies

Part 1 – General

1.1. Common Work Result

1.1.1. Power system studies will be performed using SKM Power System Analysis, Inc., “Power Tools for Windows,” or approved equivalent.

1.1.2. Studies will be conducted in accordance with ANSI/NETAATS-2017.

1.2. Fault Current Study

- 1.2.1.** An analysis will be performed to determine the maximum available fault current in amperes root mean square (rms) symmetrical at each overcurrent protective device. Calculations will specify the short-circuit interrupting and withstand ratings of all overcurrent protective devices based on the results of the calculations.
- 1.2.2.** The interrupting capacity of all overcurrent devices will equal or exceed the maximum fault current level where they are installed in the system. The system will be fully rated, meaning that the ability of the device to interrupt a fault at its terminals will not depend on the characteristics of an overcurrent device upstream. Series rated devices will not be acceptable.
- 1.2.3.** Fault current study will be submitted before or with the initial submittals for affected electrical equipment. No equipment submittals will be approved or released for procurement without full review and final approval of the fault current study.

1.3. Coordination Study

- 1.3.1.** An Overcurrent Protective Device Coordination Study will be performed in accordance with the latest version of IEEE 242. The study will include the elements described below:
 - 1.3.1.1.** The study will verify that each over-current protective device in the project is applied within its fault current rating.
 - 1.3.1.2.** The coordination study will include time current curves plotted in full scale log-log graphing (electronically generated) for all overcurrent devices. Curves for adjustable devices will be shown adjusted to afford maximum coordination with upstream and downstream devices, including devices provided by the utility company.
 - 1.3.1.3.** An initial coordination study will be submitted with the fault study to assure that proposed equipment affords the type of overcurrent device and adjustability to realize the necessary coordination between busses/devices.
 - 1.3.1.4.** A final coordination study will be submitted at least 45 working days prior to initial energizing of any equipment for testing.

1.4. Arc Flash Study

- 1.4.1.** An arc flash hazard study will be performed after the fault current and protective device coordination studies have been completed. The study will determine hazards that exist at each major piece of electrical equipment, including, switchboards, panel boards, motor control centers, UPSs, automatic transfer switches (ATSs), and transformers. The arc flash hazard study will consider operation during normal conditions, alternate operations, emergency power conditions, and any other operations which could result in maximum arc flash hazard.
- 1.4.2.** A written report will include an Arc Flash Evaluations Summary Spreadsheet, Bus Detail Sheets, and Arc Flash Hazard Warning Labels. The labels will be printed in color on adhesive backed paper, which will serve as a guide to assist technicians and others in the selection of proper Personal Protective Equipment (PPE) when working around exposed and energized conductors.
 - 1.4.2.1.** An initial arc flash study and report will be generated and submitted with the initial coordination study, to provide HAS a “first look” at implications to maintenance operations.
 - 1.4.2.2.** A final arc flash study, along with printed labels, will be submitted with the final coordination study. Labels must be confirmed by the Contractor prior to applying and will be field verified after being submitted by the Designer’s Engineer-of-Record.

1.5. Harmonics and Power Factor Study

- 1.5.1. HAS seeks to maintain a power factor of 0.95 at low extreme; the desired goal is to maximize the average power factor, while applying “best practices”, and in consideration of first and owning cost of the installation. As such, equipment of all types will be considered to assure this goal is attained.
- 1.5.2. There are many harmonic producing load types that are common within the airport environment, ranging from lighting, variable frequency drives, UPS, and 400 hertz converters. The Designer will give adequate consideration of harmonic mitigation within the design development phase of any project containing a substantial presence of harmonic producers.
- 1.5.3. Either the Designer or the Contractor’s major equipment supplier may perform the early and final harmonic analysis. However, it will bear the seal of an electrical engineer currently registered in the State of Texas.
- 1.5.4. Outcomes of this study will be presented in an acceptable manner, such as a one-line of the entire power system indicating at each node or bus a tabulation of all harmonic data, compared to IEEE recommended maximums (or if an equipment manufacturer’s recommended maximum system input harmonic data is more stringent, those limits will be used).
- 1.5.5. The study will present recommendations for additions to the system to mitigate harmonics if needed, and these costs will be in the Contractor’s proposed project cost, broken out as a section in a schedule of values.

Part 2 - Products (Not Used)

Part 3 – Execution

3.1. Audit

- 3.1.1. Prior to system testing, the Contractor will contact HAS in advance to arrange an audit of circuit breaker and relay settings, and appropriate arc flash labels.

3.1.2.

Photometric Studies

Part 1 – General

1.1. Common Work Results

- 1.1.1. Photometric studies will be performed at key points in the design to guide the overall lighting and energy analyses, and to assure illumination criteria are met in all respects. Studies will be done for both normal lighting and for emergency egress lighting.
- 1.1.2. Refer to interior and exterior lighting in this Standard for specific illumination criteria.
- 1.1.3. The studies will be submitted for review/ approval for all typical areas prior to proceeding with design completion.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Electrical Power Monitoring

Part 1 – General

1.1. Common Work Result

- 1.1.1.** At IAH, all power metering and monitoring components that are provided integral to protective devices such as circuit breakers, or installed within switchboards, switchgear and other equipment, and field installed to meter/monitor special feeders and branch circuits, shall fully integrate with a future Airport-wide energy monitoring and control system located at the CUP.
- 1.1.2.** All metering of kWhr, kW, kVA, power factor, will be utility grade accuracy.
- 1.1.3.** Sub-meters will be provided by concession tenants by the tenant’s electrical contractor. These meters will conform to HAS requirements and will be installed and tested by the tenant’s contractor in the presence of an HAS designated representative. Coordination with HAS will be needed for any other applicable requirements for such meters during design of concessions space.
- 1.1.4.** All components will be Schneider Electric (basis of design) or a HAS-approved equivalent.
- 1.1.5.** The overall system will be coordinated with HAS during design stages to assure operational goals are met.
- 1.1.6.** The system and components will facilitate future acquisition and implementation of Airport wide micro-grid capabilities. This will allow the system and components to be functionally able to operate/control and optimize energy generation and usage by dispatch control and to demand side energy management.
- 1.1.7.** System data will be backed up to “the Cloud.”
- 1.1.8.** Major control components will be redundant and digitally/data synchronized to allow seamless transfer of controls. If any of the computers fail or do not allow for system maintenance, they can be fixed remotely.
- 1.1.9.** System information will be web-enabled for remote viewing; however, control functions will be achievable only at the CUP for security reasons.
- 1.1.10.** Meters must be permanently installed, integrated into the building automation system, record at intervals of one hour or less, and capable of reporting hourly, daily, monthly, and annual energy use.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Network Lighting Controls

Part 1 – General

1.1. Common Work Results

- 1.1.1. Generally, lighting controls will be programmable, network control based, with local control stations as needed for manual operation.
- 1.1.2. Network control panels will be located with the lighting power panelboards.
- 1.1.3. The design and specification of the lighting control network system and all satellite, “slave,” or field component hardware, firmware, and software will be selected to allow compliance with the current energy code in effect. It will also provide for future expansion, upgrades, and enhancements as needed to meet future versions of energy code.
- 1.1.4. Network lighting controls will be centralized. Distributed intelligent systems will not be allowed, due to the need to minimize components around a terminal or other building spaces that will require maintenance inspecting these items in the future for replacement or adjustment.
- 1.1.5. Lighting daylight sensors, installed for energy management dimming controls, will be easily accessible and will not require moving any permanent passenger seating or other obstructions to gain access by ladders or lift equipment.
- 1.1.6. Network systems will be programmed, initially by the Contractor, using a factory trained technician to perform the tasks. The program will be readily modified in the field either from a computer workstation or the local panel itself. Moreover, the system will be web-enabled and will allow local system overrides, ON/OFF functions, etc. from any remote location to facilitate responsive maintenance in the event of emergencies. The system will utilize multiple levels of password access depending on the need to access specific functions.
- 1.1.7. Wireless based systems will not be allowed.
- 1.1.8. Network control panels may use relays or be a motor operated circuit breaker type; however, the devices and panel will be rated for the available fault current and must bear all applicable UL labels.
- 1.1.9. Any device used for controlling or switching emergency life safety lighting (per NEC Article 700) will be UL listed for the application, and all wiring must be installed in conformance with codes and standards.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Secondary Unit Substations

Part 1 – General

1.1. Common Work Results

- 1.1.1. Secondary unit substations will consist of close-coupled lineups of medium voltage SF6-design (or HAS

approved equivalent) interrupter disconnect, medium-voltage dry- type transformer, and 480 volts alternating current (VAC) metal-enclosed draw-out switchgear. Coordinate specifications for this equipment with HAS during design to ensure final selection conforms with HAS expectations and any unwritten requirements/criteria. Secondary unit substations, as described in this Section, are an HAS preference. However, there may be considerations and circumstances for a given project that require altering this style of power delivery. Such situations should be identified as early as possible in a project, so that the design development can be coordinated with HAS.

- 1.1.2.** The line-side terminations of the primary disconnect switch will provide for feed- through-connection of multiple substations on one primary feeder.
- 1.1.3.** Substations provided for new passenger terminal design will be of a “double-ended” design configuration, except the “A” and “B” lineups will not be located within the same space. A two-hour fire wall will demise the “A” and “B” substations, and each will have a 480-volt tie breaker for connecting the two to complete the “double-ended” design. The primary feeder, transformers, 480-volt main bus and tie breakers will be rated to carry the full design load of “A” PLUS “B” loads.
- 1.1.4.** Substations will include one spare circuit breaker fully outfitted in each switchgear, plus a minimum of three fully configured spare compartments, ready for circuit breaker installation. All spares and spaces will have control wiring brought out to terminal strips for future use, equivalent to active breaker positions.
- 1.1.5.** Control wiring will be Class ‘C’.
- 1.1.6.** Each spare/outfitted space compartment will be provided with an empty circuit breaker stubbed to a readily accessible location for future extension. Provide pull line and cap end of conduit. This requirement applies to any underground future circuits.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Medium-Voltage Switchgear

Part 1 – General

1.1. Common Work Results

- 1.1.1.** All medium-voltage switchgear will be arranged to provide a minimum 2-hour fire separation between switchgear and associated equipment (e.g., DC control voltage battery systems) assigned to A and B sides of dual, redundant, power distribution system. Conduits entering or leaving an A space will not traverse a B space and vice versa.
- 1.1.2.** All rooms containing medium-voltage switchgear will be sized to allow the addition of at least one circuit breaker distribution section in the future, inclusive of housekeeping pad, underground duct stub ups, and other appurtenance as may be required to affect future beneficial use.
- 1.1.3.** Dual A and B switchgear will be configured as Main-Tie-Tie-Main (M-T-T-M), or as a complete ring bus with ring tie breaker on both the A and B sides. Interconnection of main switchgear bussing will be made using conductors in rigid steel conduits.
- 1.1.4.** Controls and monitoring circuits associated with an A side will be kept totally separated from the B side to preclude simultaneous failures.
- 1.1.5.** Programmable Logic Controllers (PLC) or other centralized controllers will be redundant, and will be

physically split between the A and B sides. Each PLC/ controller will have its own uninterruptible power supply.

- 1.1.6.** Battery systems providing 125 volts of direct current (VDC) control power will be redundant, be based on the best battery selector configuration, and will be physically segregated so that the probability of losing both systems is minimized.
- 1.1.7.** Each medium-voltage installation will include a control room that is separated by a two-hour fire wall from both the A and B switchgear spaces. The control room will be large enough for a workstation desk, chair, and control panel or station to facilitate remote operation, including remote racking out and in, of circuit breakers.
- 1.1.8.** Provide circuit breaker lifting/transport cart, one per switchgear facility.
- 1.1.9.** Medium-voltage locations will also include a separate room with work table, adequately sized for adjusting and testing circuit breakers. The room will be sized to store a circuit breaker and storing circuit breaker lift/ transport cart.
- 1.1.10.** Automatic throw-over schemes between redundant busses will be break-before-make. Transfer times will be coordinated with HAS.
- 1.1.11.** Switchgear will include one spare, fully outfitted circuit breaker in each switchgear, plus a minimum of two fully configured spare compartments ready for circuit breaker installation. All spares and spaces will have control wiring brought out to terminal strips for future use, equivalent to active breaker positions.
- 1.1.12.** Control wiring will be Class 'C.'
- 1.1.13.** Each spare/outfitted space compartment will be provided with an empty conduit sized on maximum anticipated future circuit rating, stubbed to a readily accessible location for future extension. Provide pull line and cap end of conduit. This requirement also applies to any underground future circuits.
- 1.1.14.** Coordinate specifications of this equipment with HAS during design, to ensure the final selection conforms with HAS' expectations and any unwritten requirements/criteria.

Part 2 - Products

2.1. Information

- 2.1.1.** Protective relays will be manufactured by Schweitzer Engineering Laboratories (SEL). If other manufacturers are proposed, they must be approved by HAS.
- 2.1.2.** Protective relaying must conform with CPE requirements as applicable.
- 2.1.3.** All protective relays will be by the same manufacturer for all medium-voltage installations at IAH. Design to confirmed requirements for projects at Ellington and Hobby.
- 2.1.4.** Power meters will be full-function, digital, group mounted on compartment doors, and collocated with other control devices such as control and metering switches.
- 2.1.5.** Switchgear will include a partial discharge monitoring system.
- 2.1.6.** All control wiring will be designed and wired as plug-and-play. Switchgear sections communicating with other switchgear or shipping splits will be connected with pre- fabricated wiring equipped with military grade connectors to facilitate ease of re-installation on-site and to minimize faulty connections.
- 2.1.7.** Switchgear will be drawn-out, vacuum interrupter circuit breaker type, two-high stacked sections, front and rear accessible, and with hinged rear doors.

Part 3 – Execution

3.1. Testing

3.1.1. Factory Testing: Factory testing will be witnessed by HAS representatives, including commissioning representatives. A minimum of four work weeks' notice will be given to HAS in advance of scheduled testing and reconfirmed one week in advance of testing. Contractor will provide all travel, lodging, and meal cost for two designated HAS representatives for the full duration of the testing period. Certified written reports of the tests will be provided to HAS prior to shipping switchgear to the HAS site.

Low-Voltage Transformers

Part 1 - General (Not Used)

Part 2 – Products

2.1. Information

- 2.1.1.** All distribution transformers will have 120/208 volt, three-phase secondary.
- 2.1.2.** The maximum allowable rating of transformers will be 225 kilovolt-amp (kVA).
- 2.1.3.** Provide infrared scanning ports to facilitate scanning terminations.
- 2.1.4.** Provide harmonic mitigating or K-factor 9 rated transformers as applicable, based on engineering analysis. These will be used for serving sensitive electronic, harmonic producing loads, such as personal computers in offices.

2.2. Installation

- 2.2.1.** All distribution transformers will be installed on concrete housekeeping pads and will sit on isolation pads. Transformers will not be suspended, even in electrical or mechanical rooms, without HAS approval during the design stage.
- 2.2.2.** Any transformer that must be suspended from the structure above will also sit on isolation pads. Suspension mounting of transformers exceeding 75 kVA will not be permitted.
- 2.2.3.** Stacking of transformers will not be allowed without written permission of HAS during the design stage. If permission is granted for stacking, the following will apply:
 - No more than two transformers may be stacked, one installed on a housekeeping pad at floor level and one above.
 - The maximum rating of the upper transformer will be 75 kVA.
 - The support structure for the upper transformer will be of heavy, galvanized steel construction with welded joints.
 - Minimum vertical separation between the lower and upper transformer will be 15 inches.

Part 3 - Execution (Not Used)

Low-Voltage Switchgear

Part 1 – General

1.1. Common Work Results

- 1.1.1. Low voltage, arc-resistant, and draw-out switchgear.
- 1.1.2. 480/277 volt, three-phase, 60 hertz.
- 1.1.3. The space planning of electrical rooms will fully consider size and clearance requirements for the switchgear, including enough space from the installed top of the switchgear to structure above for arc venting.

Part 2 – Products

2.1. Information

- 2.1.1. Switchgear will be arc-resistant and will meet the testing requirements of IEEE C37.20.7.
- 2.1.2. Type 2B construction; front, rear, and sides.
- 2.1.3. Testing will be based on the current highest- rated circuit breaker without insertion of any current-limiting device in the test circuit.
- 2.1.4. All breakers will be 100 percent rated, equipped with full electronic trip functions, full-function metering, and communications connectivity to interface with the Power Monitoring System as described elsewhere within this Electrical Standard.
- 2.1.5. Provide zone selective interlocking.
- 2.1.6. All breakers electrically operated, spring- charged, and 125 volt AC power supplied by internal control power transformers.
- 2.1.7. Breakers will have energy-reducing maintenance setting switch. This switch will be preferably capable of activation remotely, either via a dedicated control panel or workstation in an adjoining control room.
- 2.1.8. Busses will be copper and fully-insulated.
- 2.1.9. Provide sheet metal barriers between sections.
- 2.1.10. Provide remote racking capability for all breakers, preferably from a control station in an adjoining room. However, an umbilical cable to a hand-held control station may be acceptable depending on the room layout and whatever it allows the operator well away from the arc flash area. A standard 25-foot cable may not be sufficient.
- 2.1.11. For Main-Tie-Main (MTM) operations, the throw-over will be manual and will use a Kirk-keyed interlock system to prevent more than one main being closed if the tie is closed. For MTM configuration, there will be two tie breakers, one for each A and B main busses; however, only one tie will be designated as the operable tie for the interlock, while the other tie remains normally closed.
- 2.1.12. Each breaker will be equipped with over/ under voltage relay protection, with the ability to turn these functions off and on selectively.
- 2.1.13. All secondary and control wiring will be terminated in hinged panels/compartments segregated from the power sections and bussing. Fuses will be readily accessible for all such circuits.

- 2.1.14. Provide crane rail and hoist operable by one person.
- 2.1.15. Provide test kit for field calibration of
- 2.1.16. breakers.
- 2.1.17. Provide infrared scanning ports to facilitate scanning terminations.

2.2. Function / Application

- 2.2.1. Provide double indent, two-holes, and long barrel type lugs for active and future circuits.

2.3. Flexibility / Expandability

- 2.3.1. Make drilled and plated provisions for future bus extension.

Part 3 - Execution (Not Used)

Switchboards

Part 1 - General (Not Used) Part 2 - Products

2.1. Information

- 2.1.1. Switchboards will be fully-rated for the available short circuit current and series-rated equipment is not acceptable. Main 480 volt service switchboards in the terminals will be rated 100 kAIC.
- 2.1.2. The manufacturer of the switchboard assembly will be the same as the manufacturer of the circuit breakers installed within the assembly.
- 2.1.3. The equipment, major components, and anchorage will be suitable for and certified to meet all applicable seismic requirements.
- 2.1.4. Distribution bus bars will be silver-plated or tin-plated copper and will have bus extensions, drilled and plated, provided at the ends where future sections can be added. Bus bars will be fully rated for the entire length of the switchboard.
- 2.1.5. Switchboards will be positioned so there is open space on at least one side for future additional sections.
- 2.1.6. Spare breakers and spaces will be provided for switchboards based on their anticipated future uses.
- 2.1.7. Each such spare breaker or space will have conductors in conduit installed, sized for the maximum circuit anticipated, and extended to a bussed junction box to facilitate extending the circuit in the future without having to access the switchboard.
- 2.1.8. Provide infrared scanning ports to facilitate scanning terminations.

Part 3 - Execution (Not Used)

Panelboards

Part 1 – General (Not Used)

Part 2 – Products

2.1. Information

- 2.1.1.** Panelboards will be fully-rated for the available short circuit current. Series-rated equipment is not acceptable.
- 2.1.2.** All circuit breaker assemblies having a main breaker or feeder breaker rating of 100 amps and above, will utilize bolt-on main and branch devices and copper bussing. Assemblies will also be designed to accommodate more than 18 single poles and will have door-in-door type cover.
- 2.1.3.** Panelboards will be limited to 42 poles per section; however, on a case-by-case basis, HAS may allow this limit to be exceeded by special written permission.
- 2.1.4.** Panelboards rated 400 amp and above will be provided with a hinged trim feature and a full-height piano hinge.
- 2.1.5.** Panelboard main bus bars will be copper with full capacity neutral and equipment ground bus.
- 2.1.6.** Distribution panelboards will be equipped with surge protection devices (SPD) selected for design conditions. SPDs may be integrally or externally mounted. If external; however, locate to be readily accessible and leads between SPD and panelboard will not exceed length of wire size limitations per manufacturer instructions.

Part 3 – Execution

3.1. Installation

- 3.1.1.** All recessed panelboards will have empty conduits with pull lines stubbed to an accessible location. The quantity and size of conduits will be adequate to make future use of all spare breakers and pole spaces. In no case will less than six 1-inch conduits be provided.
- 3.1.2.** All surface mounted panelboards will have empty conduits with pull lines stubbed to a point within the room so that they are readily accessible for future expansion. The quantity and size of conduits will be provided for future utilization of at least 25 percent of spare breakers and pole spaces without having to terminate additional conduits.
- 3.1.3.** Directories shall be typewritten and will indicate the loads served by each circuit and will be mounted in a holder behind a clear protective covering at the back of the panelboard door. The directory must be revised to reflect circuiting changes required to balance phase loads.
- 3.1.4.** Each branch circuit conduit will contain no more than three branch circuit phase conductors, and each conductor will be of a different phase. Shared neutrals are not permitted.
- 3.1.5.**

Motor-Control Centers

Part 1 - General (Not Used)

Part 2 - Products

2.1. Information

- 2.1.1.** Motor control center will be heavy duty industrial grade.
- 2.1.2.** All indicator and pilot lights will be LED with metal housing and easily replaceable parts.
- 2.1.3.** All control wiring will be installed in Panduit wiring ducts. Wiring will be stranded copper.
- 2.1.4.** Provide wire markers or tags for all control wiring at all termination points.
- 2.1.5.** Each plug-in unit will control only one motor, no dual starters.
- 2.1.6.** Provide a circuit breaker for the unit disconnect device, not a fusible switch.
- 2.1.7.** Provide side mounted, latched pull-apart terminal blocks for all remote-control wiring. Provide 25 percent spare terminals.
- 2.1.8.** There will be no interlock for A-B motor configuration.
- 2.1.9.** Overload reset button will be operable without wires blocking access.
- 2.1.10.** Overload relays will be electronic type.
- 2.1.11.** Provide phase failure/reversal protective relay.
- 2.1.12.** Provide three position selector switches, Hand-Off-Auto, not a Start-Stop button.
- 2.1.13.** For motors with two speeds, provide a separate High-Low selector switch.
- 2.1.14.** Wire ties will be attached to the unit with screws or epoxy, not adhesive tape.
- 2.1.15.** Provide infrared scanning ports to facilitate scanning incoming supply terminations and buss connections.
- 2.1.16.** Motor control centers will either be fully accessible for maintenance from the front only, including main supply feeder connections and branch circuits, or will be front/rear accessible and placed with the rear away from the wall at a distance per the NEC plus 24 inches requirement.

Part 3 - Execution (Not Used)

Low-Voltage Busways

Part 1 - General Part 2 – Products

2.1. Information

- 2.1.1.** Indoor busway feeders will be sprinkler- proof, IP54 rating.
- 2.1.2.** Busway joints will be readily accessible for infra-red scanning and maintenance.
- 2.1.3.** Busways will not have any other system component or obstruction below them that prevents removal of the busway if necessary.

Part 3 - Execution (Not Used)

Wiring Devices

Part 1 - General (Not Used)

Part 2 – Products

2.1. Information

- 2.1.1.** All flush wall plates for wiring devices, or with bushed openings for cables, will be stainless- steel.
- 2.1.2.** Wall plates with a bushed opening will be installed at each location where a data or telecommunications cable enters or exits a wall.
- 2.1.3.** Wall plates designed for flush mounted boxes will not be used on surface mounted boxes.

2.2. Function / Application

- 2.2.1.** Cables will only be passed through one side of a hollow wall by means of an installed flush box having a cover plate with a bushed opening.
- 2.2.2.** When cables are passed completely through any wall by horizontal penetration from one side of the wall to a space on the other side of the wall, only approved sleeves of prefabricated assemblies rated for the specific application may be used.
- 2.2.3.** Standard wiring devices may be ivory, brown, or other suitable color. However, the final color selection will be submitted for approval by HAS.
 - 2.2.3.1.** Red devices will only be used in circuits that are designated as Emergency.
 - 2.2.3.2.** Orange wiring devices will only be used in circuits that have isolated grounding conductors.
- 2.2.4.** Wiring devices that depend solely on stab-in or speed wiring terminals are prohibited.

Part 3 – Execution

3.1. Installation

- 3.1.1.** Receptacles will be installed so that the ground prong is mounted in the up position unless installed 42 inches above finished floor or higher.
- 3.1.2.** Receptacles will be flush mounted, to the extent possible. Surface mounted receptacles will not be installed in public areas.
- 3.1.3.** At a minimum, convenience receptacles will be provided as follows:
 - In offices, provide duplex receptacles at 10 feet on center maximum and a minimum of one duplex receptacle per wall.
 - In gate hold rooms, provide duplex receptacles at 12 feet on center maximum.
 - In areas with seating intended for use by passengers, provide duplex receptacles at 12 feet on center maximum.
 - In maintenance or shop areas, provide duplex receptacles at 12 feet on center maximum.
 - In corridors, provide duplex receptacles for use by maintenance personnel at 50 feet on center maximum.

- In storage and supply areas, provide duplex receptacles for use by maintenance personnel at 25 feet on center maximum.
 - Provide receptacles adjacent to sinks in toilet rooms.
 - Provide receptacles near all carousels, elevators, escalators, and other equipment that require preventative maintenance or cleaning.
 - Provide receptacles at each stairwell floor landing.
 - Provide receptacles under exterior canopies in maintenance or shop areas, provide duplex receptacles at 20 feet on center maximum.
 - Provide receptacles within 25 feet of, and on the same level as, any electrically operated equipment on rooftops, in attics, and in crawl spaces.
- 3.1.4.** Receptacles serving personal computers will be limited to two per 20 amp circuit.
- 3.1.4.1.** Receptacles serving printers in use will be limited to two per 20 amp circuit.
- 3.1.4.2.** Computer and printer receptacles will not be connected to the same circuit or to the general receptacle circuits. Laser printers will have dedicated circuits too.
- 3.1.4.3.** All computer, printer, fax, and copier circuits will be provided with dedicated neutral conductors and a separate equipment ground conductor.
- 3.1.5.** Provide a minimum of two dedicated 120 volt, 20 amp duplex receptacles in each Main Distribution Frame (MDF) or Intermediate Distribution Frame (IDF) room. Provide a dedicated 120 volt, 20 amp quadraplex receptacle for each rack or cabinet.
- 3.1.6.** Ground-Fault Circuit Interrupter (GFCI) receptacles will not be wired to protect downstream receptacles except in indoor installations where the downstream receptacles are in the same room. All floor box receptacles will be GFI protected. Receptacles serving vending machines will be GFCI type. Receptacles installed in exterior locations will be GFCI type with a UL listed While-in-Use cover.

Low-Voltage Circuit Protective Devices

Part 1 - General (Not Used)

Part 2 - Products (Not Used)

Part 3 – Execution

3.1. Installation

- 3.1.1.** Disconnect switches will be mounted to building framing members. Mounting methods, depending on direct attachment to drywall or other finish surfaces, is prohibited.
- 3.1.2.** Disconnects on the load-side of variable frequency drives will be provided with auxiliary contacts, as applicable, to facilitate electrical interlock with the variable frequency drives (VFDs) to indicate the disconnect is in the open position.

Low-Voltage Controllers

Part 1 – General

1.1. Common Work Results

- 1.1.1. Motor control centers will be arc-resistant design and will have Type C control wiring.
- 1.1.2. A VFD will be provided with three-contactor bypass/isolation, unless the VFD serves a motor which is redundant to at least one other, such as in chilled water pumping redundancy.
- 1.1.3. VFDs serving redundant pumps will be served from different sources; e.g., VFD for pump #1 will be on switchboard A and VFD for pump #2 will be on switchboard B, representing the dual configuration system.
- 1.1.4. A harmonic study (refer to the Power System Standard in this section) will be performed to ascertain the optimal, most cost-effective selection of VFDs, meeting IEEE harmonics limits, and minimizing any issues such as voltage amplification effects or harmonic heating/losses. HAS prefers ABB Ultra Low Harmonic Drives.
- 1.1.5. Duplex controllers for pump control packages will have dual control power from A and B sources outside the controller and will not rely on internal control power transformers.
- 1.1.6. VFDs will be rated for the available fault current, in both normal and bypass modes.

Part 2 – Products

2.1. Information

- 2.1.1. Starters and contactors will have control voltage of 120 volts or less; 277 or 480 volt controls are prohibited.
- 2.1.2. Motor control centers will be of industrial grade and construction quality.
- 2.1.3. Motor control centers will utilize motor circuit protectors, not fused switches.

Part 3 – Execution

3.1. Installation

- 3.1.1. Controllers of any type will be mounted to building framing members. Mounting methods that depend on direct attachment to drywall or other finish surfaces is prohibited.

Engine Generators

Part 1 – General

1.1. Common Work Results

1.1.1. UL 2200 Listed

1.1.2. Tanks UL 2085 Listed

Part 2 – Products

2.1. Manufacturers

2.1.1. Engine-generators will be Caterpillar, or a HAS-approved equivalent.

2.1.2. Engine sets will be selected during design for the appropriate application and Environmental Protection Agency (EPA) Tier level.

2.1.3. Engine-generators will be selected for full design load operation at maximum expected ambient temperature. This will be based on location and in consideration of accumulation of hot air during extended operations.

Part 3 - Execution (Not Used)

Battery Equipment

Part 1 – General

1.1. Common Work Results

1.1.1. Refer to the Static Uninterruptible Power Supply (UPS) on the following page for static UPS battery requirements.

1.1.2. Medium-voltage switchgear control power for circuit breaker control will be 125 VDC, lead-acid batteries on racks within metal enclosures, and provided with acid neutralization absorber pads at the floor level. These battery systems will be redundant and must utilize a best battery scheme with a direct current (DC) circuit breaker panelboard rated for the application. DC circuit runs will be sized for expected voltage drop and will consider any future load additions. Each switchgear will have a dedicated DC plant.

1.1.3. Battery chargers will be selected on a best practice basis.

1.1.4. A battery monitoring system will be provided for each battery installation and will have communications to the Airport-wide power monitoring system.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Static Uninterruptible Power Supply (UPS)

Part 1 – General

1.1. Common Work Results

- 1.1.1. UPS systems will be designed to balance using load power reliability with initial cost and overall project budget constraints.
- 1.1.2. UPS systems for new facilities, including, passenger terminals will be centralized, 480 volt, three-phase input and 480 volt, three-phase output. Systems will be parallel redundant, with external system bypass capability. During the schematic design stage, the Designer will evaluate at least two different schemes: one with single 480 volt feeders to each data room, the second with redundant 480 volt feeders (A/B configuration) to each data room.
- 1.1.3. At each data room, the UPS 480 volt feeder will serve a transformer that includes a local 480 volt disconnect. The transformer will be stepping down to 120/208 volt, three-phase, solidly grounded neutral that serves a circuit breaker panelboard.
- 1.1.4. If a single panelboard serves a data room, there must be coordination between the branch circuit configuration and with IT specifications and final equipment requirements.

Part 2 – Products

2.1. Information

- 2.1.1. UPS will be manufactured by Eaton only for HAS owned operated buildings. No other manufacturers will be accepted due to existing maintenance contracts.
- 2.1.2. Consideration will be given to specify scalable/modular UPS products, configured to balance initial versus ultimate future load requirements.
- 2.1.3. UPS battery: provide lead-calcium valve- regulated lead-acid (VRLA) batteries in cabinets. Batteries will be sized for 80 percent of maximum UPS kW rating. Provide for portable load bank testing of batteries within the system design. Provide means of isolating strings for multi-string battery systems and provide UPS manufacturer's best offering of battery monitoring system.
- 2.1.4. UPS system will have full monitoring, metering, alarming and, as available from the manufacturer, predictive maintenance capabilities. Monitoring systems will be configured for communications as required by the HAS IT department.

Part 3 – Execution

3.1. Installation

- 3.1.1. UPS rooms will provide for full access clearance for normal operation and maintenance, as well as ability to remove and replace major components.
- 3.1.2. Provide all safety accessories as required by codes and standards.

3.1.3. Evaluate and provide for battery off-gassing ventilation as required.

3.1.4. UPS floor-mounted components will be provided with 6-inch-high concrete housekeeping pads.

3.1.5.

Transfer Switches

Part 1 – General

1.1. Common Work Results

1.1.1. Transfer switches will be four-poled with switched neutral where switching between the two sources each have a grounded neutral.

1.1.2. Transfer switches will be open-transition, with mid-point neutral position programmable delay.

1.1.3. Transfer switches will be equipped with maintenance isolation and bypass switching feature.

1.1.4. Transfer switches will be of a contactor design, not interlocked circuit breaker type.

Part 2 – Products

2.1. Information

2.1.1. Transfer switches will be Russelectric, or a HAS-approved equivalent.

Part 3 - Execution (Not Used)

Facility Lightning Protection

Part 1 – General

1.1. Common Work Results

1.1.1. Lightning protection system will be provided for all building structures on the Airport. The lightning protection system will comply with the most current Edition of NFPA 780, Standard for the Installation of Lightning Protection Systems. Aluminum conductors shall be used for lightning protection. Installation will be made under the direct supervision of a certified master installer, whose certification has been granted by the Lightning Protection Institute (LPI). Except for cable fasteners, all components of the lightning protection system will be listed and labeled by UL.

1.1.2. For additions to buildings that already have a lightning protection system installed, provide lightning protection in the new construction only and bond to the existing system.

1.1.3. Upon completion of the work, the Contractor is required to transmit, on their letterhead, an affidavit bearing the notarized signature of the LPI Certified Master Installer. The affidavit will show that the lightning protection system complies with NFPA 780 and, in building additions,

that it has been bonded to the existing system.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Interior Lighting

Part 1 – General

1.1. Common Work Results

- 1.1.1.** The most currently released edition of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook will be used to determine design lighting levels, unless higher design/performance criteria are presented elsewhere in this Standard. To the extent possible, all such products will be certified by Design Lights Consortium (DLC). All lighting fixtures/systems will be LED type, to the extent possible. Where architectural treatments may be better served other than LED type, these design conditions will be presented to HAS for final approval.
- 1.1.2.** The following light conditions will be used as design levels during the area's predominant period of occupancy:
- Terminal waiting areas 20 Hfc
 - Terminal Concourse 10 Hfc
 - Private office area (maximum level) 5 Hfc at the work surface, task lighting is encouraged.
 - Common office area, cubicles, 40 Hfc at the work surfaces.
 - Corridors in office area 25 Hfc
 - Ticket counters and TSA Documentation review 30 Hfc
 - Baggage claim 15 Hfc
 - Jet Bridge 10 Hfc
 - Rest Rooms 10 Hfc, 5 Vfc
 - Equipment maintenance 50-75 Hfc on task plane
 - Storage 30 Vfc on shelf
 - Parking garage 5 Hfc, 3 Vfc, 10;1 Max/Min uniformity
- 1.1.3.** The following lighting quality design best practices will be considered during lighting design:
- For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m² between 45 and 90 degrees from nadir. Exceptions include wallwash fixtures properly aimed at walls, as specified by manufacturer's data, indirect uplighting fixtures, provided there is a no view down into these uplights from a regularly occupied space above, and any other specified applications (i.e. adjustable fixtures).

- For the entire project, use light sources with a CRI of 80 or higher. Exceptions include lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, or other special use.
- Use direct-only overhead lighting for 25 percent or less of the total connected lighting load for all regularly occupied spaces.

1.1.4. Provide daylighting control in perimeter spaces with a fenestration ratio equal to or higher than 30 percent, and in all atria with significant daylighting. Ensure proper selection of fixtures, proper matching of lamps and drivers/ballasts, and that these have control protocol compatible with specified control system. Select and place sensors to optimize the control system effectiveness, and adjust during testing/commissioning for optimal control. Placement of sensors and other control components will consider access for maintenance, and not be unreachable due to obstructions on the floor such as passenger seating.

Part 2 – Products

2.1. Information

2.1.1. Ballast/driver operated lighting fixtures will be equipped with individual in-line fuses located in the fixture, remote ballast/driver package, or the pole base.

2.2. Function / Application

2.2.1. Pull chain or cord operated light fixtures are prohibited.

2.3. Serviceability / Maintainability

2.3.1. Fixtures and components must be accessible and a pathway for lift equipment to maintain all lighting components will be provided for.

2.3.2. Controls or other lighting system components that are not integral to luminaires will be accessible via removable ceiling tiles or hinged access panel. Such components will be easily reachable via such portals.

Part 3 - Execution (Not Used)

Safety Lighting

Part 1 – General

1.1. Common Work Results

1.1.1. All code-required Life Safety lighting, other non-code-required night lighting, un-switched lighting in certain work areas that utilize battery inverter systems, or are controlled by contactor devices will be provided with means to quickly bypass such inverters and contactors.

- 1.1.2.** Aircraft obstruction lighting on landside and airside will be designated based on the most current FAA Advisory Circulars.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

Exterior Lighting

Part 1 – General

1.2. Common Work Results

- 1.2.1.** Poles and other structural supports for lighting will be designed for maximum hurricane wind forces as stated at this Design Guidelines. Poles will be galvanized steel, selected for the design life of the project. Provide an airgap between bottom of steel pole base and foundation concrete. Tops of pole bases will be sufficiently elevated above the maximum rainwater runoff/flooding level to assure pole bases are above any standing water.
- 1.2.2.** Runway, taxiway lighting, and visual aids will be designed based on the design standards and requirements of the most current FAA Advisory Circulars. These will be supplemented by the NEC as it pertains to vault work and the commercial power side of the vault equipment. System layout configuration, fixture utilization, and design will be specified by all current applicable FAA Advisory Circulars.
- 1.2.3.** Airport operated lighting systems will be designed for the most critical operational criteria, and to conform with existing systems to the extent possible.
- 1.2.4.** Minimum coverage for wet and dry bores for duct bank installation is 10 feet under taxiways and runways as measured from the lowest surveyed elevation of the pavement surface being crossed. Most runways and taxiways are crowned at the centerline, thus the outside edge of the paved surface, including the shoulders, would be the design elevation. Reversed crowned pavements or super elevated pavements would use the lowest pavement elevation encountered in the utility crossing alignment.

1.2. Airport Exterior Lighting

- 1.2.1.** Airfield Lighting: All airfield lighting will conform to FAA AC 150/5340-30.
- 1.2.2.** Designer will consult with HAS with respect to any proposed modifications to existing systems to ascertain current directives.
- 1.2.3. Apron Lighting**
- 1.2.3.1.** Apron lighting design requirements will consider best practice for the application, and will at a minimum meet typically used lighting criteria (e.g., the IES Recommended Practice for Airport Service Area Lighting, RP-14 [no longer in publication]). At IAH, new apron lighting design will consider the most recent lighting installed at the Airport as a guideline. The design will create the best illumination of subject area/space for the given project based upon the Project needs, specific input from HAS, and the Project Stakeholders.

- 1.2.3.2. Horizontal illumination at the pavement level which is located at the tail of the aircraft gate lead-in line, at the outboard edge vehicle service road (VSR)/Object Free Area (OFA) line as applicable, or tail of the largest design aircraft that may be parked at a given parking/gate position, will be 3 foot candles. The actual initial foot candle measurement will be verified prior to Substantial Completion of the project and remediated as necessary.
- 1.2.3.3. Illumination in the aircraft parking/ loading areas will average a nominal 10-foot candles as measured above. Vertical plane foot candle design levels will generally conform to the horizontal illumination design based on the lighting system chosen. Minimum vertical base-line criteria will conform to the following:
 - 1.2.3.3.1. Minimum vertical plane illuminance measured at a height of 3 feet above ground level (AGL). The light meter facing the poles will be 5-foot candles at 100, 150, and 200 feet.
 - 1.2.3.3.2. Maximum vertical plane illumination at the VSR will be 0.25-foot candles at a height of 50 feet AGL and 0.10-foot candles at a height of 100 feet AGL.
- 1.2.4. Designer will carefully consider the placement of lighting poles to avoid shadows. Pole heights will also be governed by FAA Part 77.
- 1.2.5. General lighting near the terminal facility is specified at approximately two maintained foot-candles.
- 1.2.6. The Designer will call for submittals of the manufacturer's lighting analysis to include point-by-point foot candle calculations to demonstrate that the proposal meets the design criteria (per RP-14).
- 1.2.7. Prior to final acceptance, the Contractor must submit a report of testing accomplished by an IES-certified agency. This will show that the installation complies with the specified criteria and the proposal calculated values. Measurements will include horizontal and vertical plane measurements at distances and heights per this Standard, unless waived in part in writing by HAS. These tests will indicate areas of unacceptable glare as indicated by FAA air traffic controllers or pilots. All testing will comply with IES recommendations. All adjustments in fixture aiming will be accomplished by the Contractor at no additional cost to HAS.

1.3. Exterior Lighting

- 1.3.1. Provide fuses and fuse holders for outdoor lighting ballasts and light pole fixtures.
- 1.3.2. All outdoor lighting systems, including air side ramps and apron lighting, roadways, parking lots, parking garages, and architectural lighting will be LED type. To the extent possible, all such products will be certified by Design Lights Consortium (DLC).
- 1.3.3. Floodlight fixtures mounted on a lowering device, preferred method, will have drivers/ ballasts installed within the fixture. Fixtures mounted on non-lowering device poles will have remotely located drivers/ballasts in a separate enclosure, mounted to the lighting pole, at an accessible height. While these are HAS preferred criteria, the Designer will strive to apply best practices for the application based on available fixture/lamp/ driver technology, with consideration given to maintenance and component replacement over the life of the facility.
- 1.3.4. Exterior lighting should conform to the luminaire backlight, uplight and glare (BUG) ratings as defined in IES TM-15-11, Addendum A.
- 1.3.5. Parking Facilities: Illumination in parking garages will be designed in accordance with IES recommendations for night and day illuminance levels, including entrances, ramps, and other zones.
- 1.3.6. The lighting system will conform to the energy code in force, as a minimum standard. However, additional controls may be considered for ASHRAE 90.1-2013 which states controls will consider enhancing safety for pedestrians and drivers, especially at entrances from streets.
- 1.3.7. Parking Lots: Illumination levels will be designed in accordance with IES recommendations, with consideration of enhanced security illuminance levels. The lighting system will conform to the energy code in force, as a minimum standard. Additional controls however, may be considered for energy savings providing such controls do not degrade security aspects. All lighting will conform to FAA criteria

for glare and other requirements.

Part 2 - Products (Not Used)

Part 3 - Execution (Not Used)

24 - FIRE PROTECTION AND ALARM SYSTEMS



24 - Fire Protection and Alarm Systems

Part 1 – General

1.1. Definitions

- 1.1.1. Authority having Jurisdiction (AHJ) An organization, office, or individual responsible for enforcing the requirements of a code or standard or for approving equipment, materials, an installation, or a procedure
- 1.1.2. **High-Pressure Piping System:** Fire-suppression piping system designed to operate at working pressure at a minimum stated at the latest AHJ codes and standards.
- 1.1.3. **Underground Service-Entrance Piping:** Underground service piping below the building.

1.2. System Descriptions

- 1.2.1. **Automatic Wet-Type, Class III Standpipe System:** Includes nominal pipe size (NPS) 1-1/2 inch hose stations and NPS 2-1/2 inch hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
- 1.2.2. **Wet-Pipe Sprinkler System:** Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
- 1.2.3. **Dry-Pipe Sprinkler System:** Automatic sprinklers are attached to piping containing compressed air and that is connected to water supply with dry valve system. Water discharges from sprinklers when upon compressed air pressure drop then dry valve releases water to the sprinklers. Sprinklers open when heat melts fusible link or destroys frangible device.
- 1.2.4. **Pre-Action Sprinkler System:** Automatic sprinklers are attached to piping containing supervising compressed air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.
- 1.2.5. **Deluge Sprinkler System:** Open sprinklers are attached to piping connected to water supply through deluge valve. Fire-detection system in same area as sprinklers opens valve. Water flows into piping system and discharges from attached sprinklers when valve opens.
- 1.2.6. Clean-agent fire-extinguishing system will be a certified pre-engineered system for total flooding of the hazard area including the room cavity below the ceiling and below the raised floor. Provide separate zones above and below the raised floor. If smoke is detected below the raised floor, agent shall be discharged in the underfloor zone only as applicable. If smoke is detected above the raised floor, agent shall be discharged in zones above and below the floor.
- 1.2.7. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, heating, ventilation, and air-conditioning (HVAC) equipment, conveyors and partition assemblies. Coordinate with Houston Airport System (HAS).
- 1.2.8. **Portable Fire Extinguishers:** Portable fire extinguishers will be provided where required by IFC inclusive of Table 906.1. Portable extinguishers will be tested in accordance with National Fire Protection Association NFPA 10.
- 1.2.9. Fire hydrant service lines will be designed per the City of Houston (COH) Infrastructure Design Manual (IDM) and approved by the AHJ.

1.3. Quality Assurance

1.3.1. Performance Requirements

- 1.3.1.1. All equipment and materials will be Underwriters' Laboratories, Inc. (UL) or Factory Mutual (FM) approved and listed and will bear the appropriate stamp or label. Entire sprinkler, fire hose cabinet, fire riser and standpipe piping must have seismic design as per Category F. The pressures should be as per National Fire Protection Association (NFPA) for standard and high-pressure systems. Where applicable (indoors), sanitary sewer design will be capable of capturing Sprinkler systems flows during testing as permitted by HAS. The rate of discharge must be compatible with capacities at the point of entry into the sewer system. All sprinkler systems will be constructed to allow for water quality sampling.
- 1.3.1.2. **Standard Piping System Component Working Pressure:** Listed for at least 150 psig minimum.
- 1.3.1.3. **High-Pressure Piping System Component Working Pressure:** Listed for 300 psig minimum.
- 1.3.1.4. Fire-suppression standpipe system design shall be approved by authorities having jurisdiction.
- 1.3.1.5. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.
- 1.3.1.6. **Margin of Safety for Available Water Flow and Pressure:** minimum 10 percent, including losses through water-service piping, valves and backflow preventers.
- 1.3.1.7. The fire sprinkler system in airport passenger terminals and HAS occupied, operated and maintained buildings will be designed for a minimum ordinary hazard type occupancy as defined by NFPA 13.
- 1.3.1.8. All sprinkler pipes that penetrate masonry or concrete walls or floors will be sleeved with schedule 40 steel pipe.
- 1.3.1.9. All sprinkler piping below 1-1/4 inches in diameter will be Schedule 40 steel pipe.
- 1.3.1.10. Main drains and inspector test valves will terminate to the exterior of the building. Discharge will not be near any pits.
- 1.3.1.11. Provide a bypass around the check valve in the fire department connection line with a control valve in the normally closed position. The bypass is required for the performance of a full flow test of the system demand through the back-flow preventer. Exception: If the main drain can achieve the flow demand of the system, no bypass is required.
- 1.3.1.12. Piping and pipe fittings for dry pipe sprinkler systems will be galvanized or black steel.
- 1.3.1.13. Each dry-pipe system will have its own air pressure supervisory switch to monitor and report both high and low air pressure conditions. The switch will be located between the air supply check valve and sprinkler alarm valve.
- 1.3.1.14. A manual shut-off valve will be provided between the hi/low switch and the main air supply line leading to the compressor. The air compressor will be hard wired directly to a lockable disconnect box or to a dedicated branch circuit.
- 1.3.1.15. Air compressors will be connected to the existing piping system via stainless- steel mesh connectors and installed with no bends. All air compressors will be installed on spring vibration isolation pads.
- 1.3.1.16. Sprinkler pipes will be thoroughly flushed in accordance with NFPA 13 and NFPA 25 each time the system is expanded or modified.
- 1.3.1.17. Where conveyors penetrate rated assemblies or floors, provide closely spaced sprinklers in combination with draft stops as follows:
 - 1.3.1.17.1. The draft stops will be located immediately adjacent to the opening will be at least 18 inches deep and of noncombustible material that will stay in place before and during sprinkler operation. Sprinklers will be spaced approximately 6 feet apart and placed 6 to 12 inches from the draft stop on the side away from the opening. An area smoke detector will be placed in the ceiling above the floor opening and wired to the fire alarm system.
 - 1.3.1.17.2. **Alternate for Floor Penetrations at Conveyors:** Conveyor openings may be provided with fire/smoke shutters that can be manually closed or automatically closed by smoke detectors installed in accordance with NFPA 72 in lieu of method described above. Smoke detectors operating

fire/smoke shutters should be monitored by the Fire Alarm Control Panel.

- 1.3.1.18. Baggage conveyor belts will be protected with sprinklers spaced no closer than 6 feet and no farther than 8 feet on centers in above ceiling areas. Sprinkler heads will clear baggage and other items. Sprinkler head guards will be installed.
- 1.3.1.19. New Fire Alarm Systems (FAS) in Terminals will be coordinated with existing HAS FAS. The FAS will be provided, tested and approved in compliance with NFPA 72 and the International Fire Code (IFC). HAS would prefer the Fire Alarm system as a standalone system and the public address (PA) system to provide secondary or auxiliary audio notification. HAS preference would be the fire alarm system would have pre-programmed announcements and provide multilingual customers with life safety related information transmitted to the PA system as supplemental audio notification. The system will include or consist of, but not be limited to the following:
 - 1.3.1.19.1. The Fire Alarm Data Gathering Panel (DGP) will function as an integral component of the HAS Central Fire/ Security System and the Intelligent System devices referenced hereinafter. The panel will be UL 864 UOJZ and UUKL listed. The location will be approved by HAS and will communicate with the Central Fire/Security System via fiber optic cable (FOC).
 - 1.3.1.19.1. The DGP will supervise Alarm Trouble and Supervisory conditions.
 - 1.3.1.19.2. All panels will be made up in a uniformly and orderly manner.
 - 1.3.1.19.3. A 120 volts alternating current (VAC) dedicated circuit will power the fire alarm panel. A label will be affixed inside the fire alarm panel as to the panel designation and breaker number of the 120 VAC power source.
 - 1.3.1.19.4. The panel will contain batteries to provide stand-by emergency power, sized to maintain the local fire alarm system operational upon loss of primary power. The batteries will have the capacity to operate the system under standby condition for 24 hours and under alarm conditions for a minimum of 5 minutes. Transfer from normal to battery power will be automatic. When a transfer, occurs the panel will report a trouble alarm to the Central Fire/Security System. The panel will provide float/ equalizing charge for the batteries.
 - 1.3.1.19.5. The panel will provide ground fault detection for the panel and device initiating circuits and will report ground faults to the Central Fire/Security System.
- 1.3.1.20. Design clean agent extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, or C fires as appropriate for areas being protected and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
- 1.3.1.21. Main Distribution Frame (MDF), Intermediate Distribution Frame (IDF) and Computer rooms will be protected as per HAS specification Division 271100 - 9. Performance, Capability, Detection and Sequence requirements will be as prescribed in NFPA 2001 and as coordinated with HAS.
- 1.3.1.22. Fire Prevention During Construction will include but not be limited to the following:
 - 1.3.1.22.1. **Comply with Chapter 14 of the Fire Code:** Fire Safety During Construction and Demolition for buildings under construction and NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations for non-building related construction.
 - 1.3.1.22.2. Underground water mains and hydrants will be installed and operational prior to proceeding with construction work above grade.
 - 1.3.1.22.3. Where required, standpipes will be installed and will be accessible for fire protection as the work progresses.
 - 1.3.1.22.4. Approved fire extinguishers will be provided in clear view on each floor at each usable exit in accordance with NFPA 10.
- 1.3.1.19.6. Houston Airport System follows the citywide contract for Fire Alarm Control Panel (FACP) selection. All HAS owned Fire Alarm Control Panels should match existing system. If supplied by tenant, tenant must consult with HAS on approved DGP and FACP manufacturers.

1.4. Shop Drawings and Submittals

- 1.4.1.** General product data will be submitted for all materials, equipment's and accessories. Product data includes:
- 1.4.1.1. Piping materials, including dielectric fittings and flexible connections sprinkler specialty fittings.
 - 1.4.1.2. Pipe hangers and supports that comply with local or HAS seismic criteria.
 - 1.4.1.3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
 - 1.4.1.4. Air compressors, including electrical data.
 - 1.4.1.5. Sprinklers, escutcheons, and guards.
Include sprinkler flow characteristics,
mounting, finish, and other pertinent data.
 - 1.4.1.6. Hose connections, including size, type, and finish.
 - 1.4.1.7. Hose stations, including size, type, and finish of hose connections; type and length of fire hoses; finish of fire hose couplings; type, material, and finish of nozzles; and finish of rack.
 - 1.4.1.8. Roof hose cabinets.
 - 1.4.1.9. Monitors.
 - 1.4.1.10. Fire hydrants.
 - 1.4.1.11. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
 - 1.4.1.12. Alarm devices, including electrical data.
- 1.4.2. Shop Drawings:** Diagram power, signal, and control wiring.
- 1.4.3. Approved Sprinkler Piping Drawings:** Working plans, prepared according to NFPA 13 that have been reviewed by the Engineer and AHJs, including the hydraulic calculations.
- 1.4.4. Field Test Reports and Certificates:** Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's Material and Test Certificate for Above ground Piping" and "Contractor's Material and Test Certificate for Underground Piping". Welding certificates. Field quality-control test reports.
- 1.4.5. Operation and Maintenance Data:** For standpipe and sprinkler specialties to include in emergency, operation and maintenance manuals. Include interfaces with FAS for local and remote system status monitoring and trouble/fire alarms.

Part 2 – Products

2.1. Manufacturers

- 2.1.1.** In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- 2.1.1.1. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified or Approved Equal.
 - 2.1.1.2. **Manufacturers:** Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2. Steel Pipe and Fittings

- 2.2.1.** Threaded-End, Schedule 40 Standard- Weight Steel Pipe: American Society for Testing and Materials (ASTM) A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed threaded ends.
- 2.2.1.1. Malleable-Iron Threaded Fittings:** American Society of Mechanical Engineers (ASME) B16.3.
- 2.2.1.2. Steel Threaded Pipe Nipples:** ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
- 2.2.1.3. Steel Threaded Couplings:** ASTM A 865 hot-dip galvanized-steel pipe where indicated.
- 2.2.1.4. Grooved-End, Schedule 40 Standard- Weight Steel Pipe:** ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and grooved ends.
- 2.2.1.5. Grooved-Joint Piping Systems:** Available manufactures will be approved by HAS.
- 2.2.1.6. Grooved-End Fittings:** UL-listed, ASTM A 536, ductile-iron casting with outside diameter (O.D.) matching steel-pipe O.D.
- 2.2.1.7. Grooved-End-Pipe Couplings:** UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe O.D. Include ductile- iron housing with keys matching steel-pipe and fitting grooves, pre-lubricated rubber gasket listed for use with housing, and steel bolts and nuts.
- 2.2.1.8. Threaded-End, Schedule 40 Steel Pipe:** ASTM A 135 or ASTM A 795, with wall thickness equal to or greater than Schedule 40; or ASTM A 795 and ASME B36.10M, Schedule 40 wrought-steel pipe; hot-dip galvanized where indicated and with factory- or field-threaded ends.
- 2.2.1.8.1. Malleable-Iron Threaded Fittings:** ASME B16.3.
- 2.2.1.8.2. Steel Threaded Pipe Nipples:** ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
- 2.2.1.8.3. Steel Threaded Couplings:** ASTM A 865 hot-dip galvanized-steel pipe where indicated.

2.3. Flexible Connectors

- 2.3.1.** Flexible connectors will be made from materials suitable for system fluid minimum, 150 psig minimum, and 300 psig minimum working-pressure rating for high pressure and ends according to the following:
- 2.3.1.1. NPS 2 inches and Smaller:** Threaded
- 2.3.1.2. NPS 2-1/2 inches and Larger:** Flanged
- 2.3.1.3. Option for NPS 2-1/2 inches and Larger:** Grooved for use with grooved-end-pipe couplings.
- 2.3.2.** Bronze-Hose, Stainless-Steel-Hose to steel or stainless-steel will be coordinated with HAS.

2.4. Corrosion-Protective Encasement for Piping

- 2.4.1. Encasement for Underground Metal Piping:** ASTM A 674 or AWWA C105, polyethylene (PE) film, 0.008 inch (0.20 millimeter) minimum thickness, tube or sheet.

2.5. Sprinkler Specialty Fittings

- 2.5.1.** Sprinkler specialty fittings will be UL listed or FM Global approved, Sprinkler specialty fittings will have 300 psig minimum working-pressure rating if fittings are components of high-pressure piping system.

2.5.2. Outlet Specialty Fittings:

2.5.2.1. **Mechanical-T and -Cross Fittings:** UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.

2.5.2.2. **Snap-On and Strapless Outlet Fittings:** UL 213, ductile-iron housing or casting with gasket and threaded outlet.

2.5.3. **Sprinkler Drain and Alarm Test Fittings:** Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.

2.5.4. **Sprinkler Branch-Line Test Fittings:** Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.

2.5.5. **Sprinkler Inspector's Test Fitting:** Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.

2.5.6. **Drop-Nipple Fittings:** UL 1474, adjustable with threaded inlet and outlet, and seals.

2.5.7. **Dry-Pipe-System Fittings:** UL listed for dry- pipe service.

2.6. Listed Fire-Protection Valves

2.6.1. Valves will be UL listed or FM approved. Valves shall have 300 psig minimum pressure rating if valves are components of high-pressure piping system.

2.6.2. Gate Valves with Wall Indicator Posts:

2.6.2.1. **Gate Valves:** UL 262, cast-iron body, bronze mounted, with solid disc, non-rising stem, operating nut, and flanged ends.

2.6.2.2. **Indicator Posts:** UL 789, horizontal- wall type, cast-iron body, with operating wrench, extension rod, locking device, and cast-iron barrel.

2.6.3. **Ball Valves:** Comply with UL 1091, except with ball instead of disc.

2.6.3.1. **NPS 1-1/2 inches and Smaller:** Bronze body with threaded ends.

2.6.3.2. **NPS 2 and NPS 2-1/2 inches:** Bronze body with threaded ends or ductile-iron body with grooved ends.

2.6.3.3. **NPS 3 inches:** Ductile-iron body with grooved ends.

2.6.4. Butterfly Valves: UL 1091.

2.6.4.1. **NPS 2 inches and Smaller:** Bronze body with threaded ends.

2.6.4.2. **NPS 2-1/2 inches and Larger:** Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.

2.6.5. **Check Valves NPS 2 inches and Larger:** UL 312, swing type, cast-iron body with flanged or grooved ends.

2.6.6. **Gate Valves:** UL 262, outside stem and yoke (OS&Y) type.

2.6.6.1. **NPS 2 inches and Smaller:** Bronze body with threaded ends.

2.6.6.2. **NPS 2-1/2 inches and Larger:** Cast-iron body with flanged ends.

2.6.7. **Indicating Valves:** UL 1091, with integral indicating device and ends matching connecting piping.

2.6.7.1. **Indicator:** Electrical, 120 VAC, pre-wired, 2 circuit, supervisory switch visual.

2.6.7.2. **NPS 2 inches and Smaller:** Ball or butterfly valve with bronze body and threaded ends.

2.6.7.3. **NPS 2-1/2 inches and Larger:** Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

2.7. Unlisted General-Duty Valves

- 2.7.1. Ball Valves NPS 2 inches and Smaller:** Manufacturer's Standardization Society (MSS) SP-110, 2 piece copper-alloy body with chrome-plated brass ball, 600 psig minimum cold working pressure (CWP) rating, blowout-proof stem, and threaded ends.
- 2.7.2. Check Valves NPS 2 inches and Smaller:**
MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.
- 2.7.3. Gate Valves NPS 2 inches and Smaller:** MSS SP-80, Type 2, Class 150 minimum, with bronze body, solid wedge, and threaded ends.
- 2.7.4. Globe Valves NPS 2 inches and Smaller:** MSS SP-80, Type 2, Class 150 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.8. Specialty Valves

- 2.8.1. Sprinkler System Control Valves:** UL listed or FM approved, cast- or ductile-iron body with flanged or grooved ends, and 150 psig minimum pressure rating. Control valves will have 300 psig minimum pressure rating if valves are components of high-pressure piping system.
- 2.8.1.1. Alarm Check Valves:** UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber and fill-line attachment with strainer.
- 2.8.1.2. Drip Cup Assembly:** Pipe drain without valves and separate from main drain piping.
- 2.8.1.3. Dry-Pipe Valves:** UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
- 2.8.1.4. Air-Pressure Maintenance Device:** UL 260, automatic device to maintain correct air pressure in piping. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14 to 60 psig adjustable range, and 250 psig maximum inlet pressure.
- 2.8.1.5. Air Compressor:** UL 753, fractional horsepower.
- 2.8.1.6. Deluge Valves:** UL 260, cast-iron body, hydraulically operated, differential-pressure type. Include bronze seat with O-ring seals, trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
- 2.8.1.7. Wet, Pilot-Line Trim Set:** Include pressure gage to read push-rod chamber pressure, globe valve for manual operation of deluge valve, and connection for actuation device.
- 2.8.2. Pressure-Regulating Valves:** UL 1468, brass or bronze, NPS 1-1/2 inch and NPS 2-1/2 inches, 400 psig minimum rating. Include female NPS inlet and outlet, adjustable setting feature, and straight or 90 degree angle pattern design as indicated.
- 2.8.3. Automatic Drain Valves:** UL 1726, NPS 3/4 inch, ball-check device with threaded ends.

2.9. Sprinklers

- 2.9.1.** Sprinklers will be UL listed or FM approved. Sprinklers will have 300 psig minimum pressure rating if

sprinklers are components of high-pressure piping system.

2.9.2. Automatic Sprinklers: With heat-responsive element complying with the following:

2.9.2.1. UL 199, for nonresidential applications.

2.9.2.2. UL 1767, for early-suppression, fast-response applications.

2.9.3. Sprinkler Types and Categories will be as per NFPA. Features, options, finishes, coatings and escutcheons will be coordinated with HAS and the Architect.

2.9.4. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler as required.

2.10. Hose Connections

2.10.1. Will be coordinated with HAS and as described in 1.4. above.

2.11. Hose Stations

2.11.1. Description: UL 47, semiautomatic hose stations. Threads and Gaskets: NFPA 1963 and matching local fire department threads. Fire Hose: NFPA 1961 and UL 219, lined fire hose with couplings, gaskets, and nozzle.

2.11.1.1. **Nozzles:** UL 401.

2.11.1.2. **Drain Valves:** UL 1726.

2.11.1.3. **Mountings:** Pipe clamp or wall bracket for freestanding escutcheon for cabinet-mounted units.

2.12. Wall-Type Fire Hydrants

2.12.1. Description: Cast-brass body with brass, wall, three-way escutcheon plates; brass, lugged caps with gaskets and brass chains; and brass, lugged swivel connections.

Include outlets with threads according to NFPA 1963 and matching local fire department sizes and threads, 2^{1/2} inch inlet with pipe threads caps and chain, extension pipe nipple, and valve control also matching local fire department sizes and threads.

2.12.1.1. **Type:** Flush mounting.

2.12.1.2. **Escutcheon Plates:** Square or rectangular.

2.12.1.3. **Finish:** Polished chrome-plated.

2.12.1.4. **Hydrant, Escutcheon-Plate Marking:** "HYDRANT."

2.12.1.5. **Hydrant, Valve Control:** Wall-mounting assembly with extension rod for manual control of valve inside building.

2.12.1.6. **Hydrant, Valve Escutcheon Plate Marking:** "HYDRANT VALVE CONTROL."

2.12.2. Free Standing: Fire hydrants will be 5 inches. Hydrants will be a breakaway traffic model with 6-inch mechanical joint shoe, to be buried at 5 feet, except where a different depth is shown in the hydrant schedule. Hydrants will have one 5-inch Storz outlet and 2^{1/2} inch outlets with National Standard Threading. All hydrants will meet the requirements of AWWA C502.

2.12.2.1. Subsurface hydrants are not allowed for use at HAS facilities except

when approved by the Fire Marshal. Subsurface, or flush-mount, fire hydrants will be flush type models with box and cover per COH, IDM, and the Fire Marshal's office. All subsurface fire hydrants will have a 7-foot diameter solid red circle painted around the access cover to identify its location and

use as a fire hydrant. The marking may be reduced in size when appropriate to keep from encroaching on any airfield operations pavement marking.

2.12.2.2. All Hydrants will be approved by the AHJ and all fire hydrants will be cathodically protected.

2.13. Fire Department Connections

2.13.1. Wall-Type, Fire Department Connection: UL 405 with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, 2^{1/2} inch outlet with pipe threads also matching local fire department sizes and threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE".

2.13.1.1. **Type:** Flush, with four inlets and square or rectangular escutcheon plate.

2.13.1.2. **Type:** Exposed, projecting, with two inlets and round escutcheon plate.

2.13.1.3. **Finish:** Polished chrome-plated.

2.14. Sprinkler Alarm Devices

2.14.1. Alarm-device types will match piping and equipment connections.

2.14.2. Pressure Switch: UL 753, electrical- supervision-type, water-flow switch with retard feature. Include single-pole, double- throw, normally closed contacts and design that operates on rising pressure and signals water flow.

2.14.3. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

2.14.4. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

2.15. Pressure Gages

2.15.1. Description: UL 393, 3-1/2 inches to 4-1/2 inches diameter, dial pressure gage with range of 0 to 300 psig minimum.

2.15.2. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.

2.15.3. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

2.16. Fire Alarm Devices

2.16.1. Initiating Device circuits will be "four wire" whereby the circuits are supervised for opens and grounds and lop initiating will continue to operate with a trouble such as a single open or a single ground. Supervisory and indicated circuits will be two wire supervised, with the appropriate end of line resistor installed at the last device on the loop and will receive power and communicate over the same pair of wires.

2.16.2. Fire alarm panel will not be used for junction boxes or pull boxes. There is to be absolutely no splicing inside the panel.

2.16.3. Additional devices will be capable of being added to the intelligent loop circuit by tee tapping from any point in the circuit without affecting any existing device address or function.

- 2.16.4.** Each device will contain screw terminals on rising plates for positive termination of up to 12 American Wire Gauge (AWG) wire.
- 2.16.5.** Duct and area smoke detectors will be provided with remote test and reset panels when detector is not readily accessible from floor level.
- 2.16.6.** No intelligent devices are allowed in confined spaces. Should a device be needed in a confined space, a remote monitor module will be provided in an approved location.
- 2.16.7.** All intelligent device base plates will be labeled with device address and panel loop number. The type of module will be identified as either a control module or monitor module.
- 2.16.8.** All intelligent sensors will mount on a common base to facilitate the change of sensor type if building conditions change. Base will be incompatible with conventional detectors to prevent the mounting of non- intelligent devices.
- 2.16.9.** Each sensor will contain a light-emitting diode (LED) that blinks each time the device is scanned by the DGP. If the device is in alarm, the LED will remain on to indicate the alarm condition.
- 2.16.10.** Each sensor will be capable of being tested for alarm condition via command from the DGP.
- 2.16.11.** Each sensor will respond to the DGP poll for information with its device type identification to preclude inadvertent substitution of another sensor type.
The DGP will operate with the installed device but will indicate a trouble condition until the proper type is installed or the programmed sensor type is changed.
- 2.16.12.** Each sensor will respond to the DGP poll for information with an analog representation of measured smoke density, particles of combustion, or temperature.
- 2.16.13.** Photoelectric smoke sensors will contain an optical sensing chamber with a nominal sensitivity of 2.3 percent/foot obscuration.

2.17. Monitor Modules

- 2.17.1.** The intelligent monitor module will provide an addressable input for normally open or normally closed contact devices
- 2.17.2.** The monitor module will provide a supervised initiating circuit, able to connect to either two wire supervised or four wire fault tolerant circuits.
- 2.17.3.** The monitor module will contain an LED, which will blink upon DGP scan. The LED will latch on upon determination of an alarm condition.
- 2.17.4.** The module will have an LED that will blink on DGP poll. Upon activation of the module, the LED will be latched on.
- 2.17.5.** The control module shall mount in a standard 4-inch by 4-inch deep electrical box.

2.18. Initiating Devices

- 2.18.1.** Ionization Duct Smoke Detectors will be rated at 24 volts of direct current (VDC) and be listed for applications involving air handling systems. Detector will be installed in accordance with its listing.
- 2.18.2.** Manual stations will be of rugged die cast metal construction designed for semi-flush mounting. The initiating circuit will be four wire fault tolerant. Each manual station will connect to a monitor module applicable to the DGP and will be addressable.
- 2.18.3.** Wet sprinkler systems will have vane type sprinkler flow switches. Flow switches should be set to activate between 60 and 90 seconds. The device will have a Single- Pole, Double-Throw (SPDT) that will close upon water flow.
- 2.18.4.** Dry sprinkler system alarm switches will be pressure activated and installed in accordance with the trim

specifications of the dry pipe valve.

- 2.18.5.** Supervisory switches for fire protection systems will be installed in accordance with their listing. Lanyard type supervisory switches are not permitted except as approved by the HAS Technology Section.
- 2.18.6.** Dry system air pressure switches will be installed to monitor both high and low air pressure conditions.
- 2.18.7.** Each initiating device will connect to a separate monitor module. The initiating circuit will be four wire fault tolerant.
- 2.18.8.** Supervisory devices may be connected to a single monitor module when located in the same room. Supervisory circuit will be two wire supervised circuits, with the appropriate end of line resistor installed at the last device on the loop.

2.19. Wiring

- 2.19.1.** Wiring will be in accordance with the National Electric Code, these specifications, and the approved wiring diagram.
- 2.19.2.** No wiring other than fire alarm indicator, indicating, low voltage power, and communications circuits are permitted in fire alarm conduit.
- 2.19.3.** Wiring will be completely installed; field connections made and tested for stray voltage, short circuits, and ground faults prior to connection to the intelligent modules. Stranded wires will terminate at both the device and module with spade terminals sized to fit both the wire and screw terminal.
- 2.19.4.** Color-coding of device initiating fault tolerant loops will be two conductors of one color and the other two conductors are of a different color. Colors will be continuous throughout the entire loop. Where more than one initiating loop is routed in a single conduit, the colors associated with any loop contained in the conduit will be different from the colors of any other initiating loop contained in the conduit.
- 2.19.5.** All loop wiring will be identified by ins and outs. “Ins” is defined as coming from the panel.
- 2.19.6.** Red and Black must be used for 24 volt panel power.
- 2.19.7.** No voltage supply from any other source than the primary power 120 VAC and the panel 24 VDC power supply will be utilized.
- 2.19.8.** Intelligent loop circuits must be labeled at all junction locations by the panel number and loop number. Said circuits will be provided with adequate junction boxes be expandable and provide a means for connecting to the loop in the junction box.
- 2.19.9.** Control and other panels will be mounted with sufficient clearance for observation and testing. Fire alarm junction boxes will be clearly marked for distinct identification.
- 2.19.10.** Wiring will be in electrical metallic tubing (EMT) conduit, minimum 1 inch. Flexible conduits, mounting boxes, junction boxes (which will be painted red according to HAS Electrical Standards) and panels will be securely fastened with appropriate fittings to insure positive grounding throughout the entire system. Conduits will enter the panels from the sides or bottom. Where flexible conduits are used to connect device loop wiring to alarm device, the contractor is permitted to use ½ inch flexible conduit. Refer to Division 16 “ELECTRICAL” for additional requirements for conduit.
- 2.19.11.** All fire alarm junction boxes must be mounted in approved locations for ease of maintenance from floor level.
- 2.19.12.** Backbone termination boxes must be of sufficient size to allow for termination.
- 2.19.13.** All junction boxes must be made up in a uniformly and orderly manner.

Part 3 – Execution

3.1. Installer Qualifications

- 3.1.1.** Installer's responsibilities include designing, furnishing, installing, testing and certifying fire-suppression systems and providing professional fire protection engineering services needed to assume engineering responsibility. Design basis calculations must be based on results of actual fire-hydrant flow test.
- 3.1.2. Engineering Responsibility:** Preparation of working plans, calculations, and field test reports by a qualified fire protection engineer.
- 3.1.3. Welding:** Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- 3.1.4. NFPA Standards:** Fire-suppression- system equipment, specialties, accessories, installation, and testing will comply with the following:
- NFPA 10, "*Standard for Portable Fire Extinguishers*"
 - NFPA 13, "*Installation of Sprinkler Systems*"
 - NFPA 14, "*Installation of Standpipe, Private Hydrant and Hose Systems*"
 - NFPA 15, "*Installation of Deluge Water Spray Systems*"
 - NFPA 24, "*Installation of Private Fire Service Mains and Their Appurtenances*"
 - NFPA 70, "*National Electrical Code*"
 - NFPA 72, "*National Fire Alarm and Signaling Code*"
 - NFPA 230, "*Fire Protection of Storage*"
 - NFPA 415, "*Standard on Airport Terminal Buildings, Fueling Ramp Drainage and Loading Walkways*"
 - NFPA 2001, "*Clean Agent Fire Extinguishing Systems*"
- 3.1.5.** Unless accepted otherwise by the Engineer, use manufacturers and installers that employ a Quality Management System complying with the program described in International Organization for Standardization (ISO) 9001, or similar system.

3.2. Preparation

- 3.2.1.** FAS will be provided, installed, tested, and approved in compliance with NFPA 72, NFPA 70, International Fire Code and Division 16 "*Electrical and Communications.*" Fire alarm submittals are required and will be reviewed and approved by the Fire Marshall.
- 3.2.2.** Perform fire-hydrant flow test according to NFPA 13, NFPA 14 and NFPA 291. Use results for system design calculations required in Part 1 "*Quality Assurance*" Article.
- 3.2.3.** Report test results promptly and in writing to the Engineer and AHJs.

3.3. Testing

3.3.1. Examination

- 3.3.1.1.** Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.
- 3.3.1.2.** Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.
- 3.3.1.3.** Proceed with installation only after unsatisfactory conditions have been corrected.

3.3.2. Piping Applications, General

- 3.3.2.1.** Shop-weld pipe joints where welded piping is indicated.
- 3.3.2.2.** Do not use welded joints for galvanized- steel pipe.

- 3.3.2.3. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in above ground applications, unless otherwise indicated.
- 3.3.2.4. **Piping between Fire Department Connections and Check Valves:** Galvanized or black steel, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
- 3.3.2.5. **Underground Service-Entrance Piping:** Carbon steel, grooved-end pipe and fittings; grooved-end-pipe couplings; and grooved joints. Include corrosion-protective encasement.
- 3.3.3. Standpipe System Piping Applications**
 - 3.3.3.1. Standard-Pressure, Wet-Type Standpipe System, 175 psig Working Pressure.
 - 3.3.3.2. Standard-Pressure, Dry-Type Standpipe System, 175 psig Working Pressure.
- 3.3.4. Sprinkler System Piping Applications**
 - 3.3.4.1. Standard-Pressure, Wet-Pipe Sprinkler System, 175 psig Working Pressure.
 - 3.3.4.2. Standard-Pressure, Dry-Pipe Sprinkler System, 175 psig Working Pressure.
- 3.3.5. Valve Applications**
 - 3.3.5.1. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 3.3.5.2. **Listed Fire-Protection Valves:** UL listed and FM approved for applications where required by NFPA 13 and NFPA 14.
 - 3.3.5.2.1. Shutoff Duty: Use ball, butterfly, or gate valves.
 - 3.3.5.3. **Unlisted General-Duty Valves:** For applications where UL-listed and FM Global-approved valves are not required by NFPA 13 and NFPA 14.
 - 3.3.5.3.1. **Shutoff Duty:** Use ball, butterfly, or gate valves.
 - 3.3.5.3.2. **Throttling Duty:** Use ball or globe valves.
 - 3.3.6. Joint Construction**
 - 3.3.6.1. Install piping as described below, unless piping Sections specify otherwise. Individual relevant Division piping Sections specify unique piping installation requirements.
 - 3.3.6.2. **Threaded Joints:** Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 inches with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.
 - 3.3.6.3. **Twist-Locked Joints:** Insert plain-end piping into locking-lug fitting and rotate retainer lug one-quarter turn.
 - 3.3.6.4. **Pressure-Sealed Joints:** Use UL-listed tool and procedure. Include use of specific equipment, pressure-sealing tool, and accessories.
 - 3.3.6.5. **Mechanically Formed, Copper-Tube- Outlet Joints:** Use UL-listed tool and procedure. Drill pilot hole in copper tube, form branch for collar, dimple tube to form seating stop, and braze branch tube into formed-collar outlet.
 - 3.3.6.6. **Grooved Joints:** Assemble joints with listed coupling and gasket, lubricant, and bolts.
 - 3.3.6.6.1. **Ductile-Iron Pipe:** Radius-cut-groove ends of piping. Use grooved-end fittings and grooved-end-pipe couplings.
 - 3.3.6.6.2. **Steel Pipe:** Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
 - 3.3.6.6.3. **Dry-Pipe Systems:** Use fittings and gaskets listed for dry-pipe service.
 - 3.3.6.7. **Dissimilar-Metal Piping Joints:** Construct joints using dielectric fittings compatible with both piping materials.
 - 3.3.6.7.1. **NPS 2 inches and Smaller:** Use dielectric unions, couplings or nipples.

3.3.6.7.2. **NPS 2-1/2 inches to NPS 4 inches:** Use dielectric flanges.

3.3.6.7.3. **NPS 5 inches and Larger:** Use dielectric flange insulation kits.

3.3.7. Service-Entrance Piping

3.3.7.1. Connect fire-suppression piping to water- service piping of size and in location indicated for service entrance to building

3.3.7.2. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping as per NFPA.

3.3.8. Piping Installation

3.3.8.1. Install piping as described below, unless piping Sections specify otherwise. Individual relevant Division piping Sections specify unique piping installation requirements.

3.3.8.2. **Locations and Arrangements:** Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

3.3.8.2.1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Engineer before deviating from approved working plans.

3.3.8.3. Install underground ductile-iron service- entrance piping according to NFPA 24 and with restrained joints. Encase piping in corrosion-protective encasement.

3.3.8.4. Install underground copper service- entrance piping according to NFPA 24. Encase piping in corrosion-protective encasement.

3.3.8.5. **Hangers and Supports:** Comply with NFPA 13 for hanger materials.

3.3.8.5.1. Install standpipe system piping according to NFPA 14.

3.3.8.5.2. Install sprinkler system piping according to NFPA 13.

3.3.9. Valve Installation

3.3.9.1. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and NFPA 14 and the Authorities Having Jurisdiction.

3.3.9.2. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

3.3.9.3. **Valves for Wall-Type Fire Hydrants:** Install non-rising-stem gate valve in water- supply pipe.

3.3.9.4. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

3.3.9.5. **Fire Department Connections:** All Fire Department Connections (FDC) will be a 2^{1/2} inch NPT siamese connection with a 30 degree down angle and approved by the AHJ.

3.3.10. Sprinkler Applications

3.3.10.1. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types.

3.3.10.1.1. **Rooms without Ceilings:** Upright sprinklers.

3.3.10.1.2. **Rooms with Suspended Ceilings:** Pendent, recessed, flush, and concealed sprinklers, as indicated.

3.3.10.1.3. **Wall Mounting:** Sidewall sprinklers.

3.3.10.1.4. **Spaces Subject to Freezing:** Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.

3.3.10.1.5. **Deluge-Sprinkler Systems:** Upright and pendent open sprinklers.

3.3.10.1.6. **Special Applications:** Extended- coverage, flow-control, and quick- response sprinklers where indicated.

3.3.10.1.7. Sprinkler Finishes will be coordinated and approved by the Architect.

3.3.10.1.8. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels and tiles or as coordinated with the reflective ceiling plan.

3.3.11. Hose-Connection Installation

3.3.11.1. Fire hoses, where required, will be stored in a hose cabinet. Hose cabinets exposed to the weather will be marine grade enclosures. Refer to relevant Architectural Section for cabinets, all cabinets will be coordinated with the Architect.

3.3.12. Monitor Installation

Install monitor bases securely attached to building substrate.

3.3.13. Labeling and Identification

3.3.13.1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14.

3.3.14. Field Quality Control

3.3.14.1. Perform the following field tests and inspections and prepare test reports:

- 3.3.14.1.1. **Leak Test:** After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- 3.3.14.1.2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 3.3.14.1.3. Energize circuits to electrical equipment and devices.
- 3.3.14.1.4. Start and run excess-pressure pumps.
- 3.3.14.1.5. Start and run air compressors.
- 3.3.14.1.6. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
- 3.3.14.1.7. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
- 3.3.14.1.8. Coordinate with fire alarm tests. Operate as required.
- 3.3.14.1.9. Coordinate with fire-pump tests. Operate as required.
- 3.3.14.1.10. Verify that equipment hose threads are same as local fire department equipment.

3.3.14.2. Report test results promptly and in writing to the Engineer and Authorities Having Jurisdiction.

3.3.15. Cleaning and Protection

- 3.3.15.1. Clean dirt and debris from sprinklers.
- 3.3.15.2. Remove and replace sprinklers with paint other than factory finish.
- 3.3.15.3. Protect sprinklers from damage until Final Completion.

3.3.16. Demonstration

3.3.16.1. Engage a factory-authorized service representative to train Employer's maintenance personnel to adjust, operate, and maintain specialty valves.

3.4. Operations

3.4.1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

3.4.1.1. **Sprinkler Cabinets:** Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

25 - PLUMBING



25 – Plumbing

Part 1 – General

1.1. Introduction

- 1.1.1. Design will comply with requirements of the Uniform Plumbing Code (UPC), the Uniform Mechanical Code (UMC), and coordinated with Houston Airport System (HAS). All products and piping will comply with National Sanitation Foundation (NSF) 61.
- 1.1.2. Discharge of sump pumps to the storm sewer system is prohibited without written approval from the Houston Airport System (HAS).
- 1.1.3. For public restrooms, non-public restrooms and janitor closet rooms, the designer will consider fixtures and accessories that comply with latest HAS Public Restroom Design intent for best cleaning practices.

1.2. Quality Assurance

- 1.2.1. The Plumbing System Designer (Designer) will study water usage periods and will operate pumps just prior to usage periods and limit operation of pumps as much as possible. A 7-day, 12-hour timer will be installed to control pump operation, especially during peak demand periods, as an energy reduction measure. Design, fabrication, construction, final inspection, and testing will follow International Organization for Standardization (ISO) 9001.
- 1.2.2. Design considerations will also include the involvement of HAS Infrastructure, operations and maintenance, and electric shops staff. Stakeholder involvement during design charrettes is key to the Quality Assurance Program.
- 1.2.3. Submittals will be prepared in accordance with Division 1 Specifications and the Designer's technical specifications.

1.3. Warranty

- 1.3.1. Warranties will be as provided in Part 2 of this Standard. Consult with HAS if additional warranties are beneficial for the specific project.

Part 2 – Products

2.1. Information

- 2.1.1. Motors will be American National Standards Institute (ANSI)/National Electrical Manufacturers Association (NEMA) MG 1 high efficient min.

2.2. Pipe Materials

- 2.2.1. All pipes must be adequately supported throughout and will withstand the effect of gravity loads and

stresses. Generally, hangers will be split ring or clevis type; however, trapeze hangers constructed of steel channels with welded spacers and steel rods may be specified. An engineered system may use pre-engineered hangers and supports. All hangers and supports will comply with Manufacturer's Standardization Society (MSS) Standards. Vertical pipes must be supported at each floor with pipe clamps. All piping system that are exposed or prone to freezing shall be protected by heat tracing and insulation with metal cladding.

2.2.2. Piping: Piping must meet the following requirements, unless noted otherwise:

- **Domestic Cold Water (inside):** K or L copper with silver solder (95-5) no lead.
- **Domestic Cold Water (outside):** Cast iron mechanical joint Class 150 or polyvinyl chloride (PVC).
- **Domestic Hot Water (inside):** K or L copper with silver solder (95-5) no lead.
- **Domestic Hot Water (outside above ground only):** K copper or steel with silver solder (95-5) no lead, where applicable.
- **Sanitary Sewer (inside):** Cast iron above grade, PVC below grade.
 - For highly acidic waste at sinks or equipment inclusive but not limited to USDA grinders (food prep) or concession areas - PVC above and below grade.
- **Sanitary Sewer (outside):** PVC.
- **Subsoil Drainage:** Perforated PVC, PVC.
- **Heating, Ventilation and Air- Conditioning (HVAC) Equipment Unit Drains:** Hard drawn copper drainpipe with silver solder (95-5) no lead or PVC CPVC.
- **Equipment Vents:** Steel.

2.2.3. Provide pipe saddles fabricated from galvanized metal, for insulated pipe, extending at least 12 inches in length and covering a minimum of half-pipe circumference.

2.2.4. Insulating Unions and Adapters: Provide dielectric insulating unions or adapters as required between copper pipe, steel pipe, and equipment. Dielectric insulators/adapters will contain nylon insulation.

2.2.5. Proper vibration isolation will be provided to prevent excessive noise or transmission of vibration to the building structure. This is due to the operation of machinery or equipment, or due to interconnected piping, ductwork, or conduit.

2.2.5.1. A single vibration isolation manufacturer will supply equipment for any one project.

2.2.5.2. The vibration isolation manufacturer and manufacturer's representative will have been engaged in the business of vibration isolation for no less than five years.

2.2.6. Provide an 18-inch air chamber at each hot and cold-water outlet adjacent to the fixture outlet. Diameter of chamber will be a minimum of 1½ times that of the service line to the fixture device.

2.2.6.1. Chamber and cap will be of the same material as supply piping.

2.3. Pumps

2.3.1. In-Line Circulating and Booster Pumps: Pumps will be lead free. All the water touching parts will stainless-steel or NSF rated material for domestic water service. Provide a line size ball valve on suction and discharge side of the pump. Provide unions or bolted flange connection on each side of the pump. Sleeve type bearings are acceptable for in-line pumps. Pumps will be controlled by cascade control system with VFD control system. Booster pumps where allowances permit will be packaged set with stainless steel manifold and delivered as a set. All booster sets will be controlled by cascade control system with VFD control system. The panel will function and keep on constant speed cascade operation in case of VFD failure. The Booster sets will be equipped with Nitrogen fill compression tank adequately sized for system.

2.3.2. Submersible Pumps: Generally, submersible pumps are avoided where possible except electric power manholes. Diaphragm actuated pumps are preferred rather than float actuated pumps.

2.3.3. Sump Pumps: Duplex sump pumps are required when located in a mechanical/electrical equipment

room containing high voltage switchgear or motor control panels. Provide a mechanical alternator on duplex pumps and provide a separate circuit and circuit breaker for each pump. Provide ball type check valves, bypass pipe work, and valves and float switches suitable for application as required. Pumps will be complete with automatic float switch with rod, rod guide, and copper float. Pumps will be of the wet-pit type, complete with gas tight sump cover, curb ring, and grease lubricated, Pumps will be heavy-duty, fully submersible, vertical centrifugal, grinder for sanitary and open non-corrosive vortex impeller type for sump with vertical drip-proof type motor with anti-friction grease lubricated bearings. Where sump pumps are installed to provide protection for mechanical/electrical equipment, a high-water alarm bell will be provided in the area and alarm contacts will be provided for a central monitoring system.

2.3.4. Where pumps of any type are installed in a lift station, they will be equipped with a high-water alarm, a red flashing beacon to indicate alarm status, and remote/visual monitoring capabilities, matching HAS used systems.

2.3.5. Sewer Ejector Pumps: Sewer ejector pump design and selection design criteria are the same as those listed for sump pumps, except sewer ejector pumps will be of the standard 3-inch, grinder type. These are specifically designed and installed for the purpose intended.

2.4. Drains

2.4.1. Floor Drains: All toilet rooms will be equipped with at least one floor drain or minimum number as required by the applicable code. A trap primer system will be provided for floor drains in public restrooms. Do not locate drains under equipment, machinery, cabinets, appliances, etc. or within 6 inches of any wall. All floor drains must be readily accessible. Drains will have sealed leaves to prevent odors resulting from infrequent use. Trap guards may be used in lieu of trap primers.

2.4.2. Roof Drains: Roof drains will be compatible with the roof system and will not be located within the structure. The Designer will use Houston's rainfall intensity guideline for sizing roof drains.

2.4.3. Sanitary Sewer (outside): Refer to the HAS Sanitary Sewer Design Standards.

2.4.4. Grease Traps: Wastewater from disposers, sinks, dishwashers, floor drains, and floor sinks in food service facilities will drain to a grease collection system or through a grease trap or grease interceptor serving one or more facilities. Installation will comply with the applicable plumbing code. Kitchen areas will have under sink automatic grease traps.

2.4.5. All grease waste piping will be insulated. Additionally, exposed piping will have an outer metal jacket.

2.4.6. Sanitary sewer systems conveying, or potentially conveying grease will consider design with cleanouts at 50 foot intervals.

2.4.7. ALL F&B/Retail build outs (if it requires a three compartment sink or more) must provide a certified letter by the plumbing sub-contractor, that a "Dye Test" was performed to ensure proper grease line usage and routing to grease trap/grease interceptor prior to release of Final Certificate of Occupancy.

2.5. Water Heaters

2.5.1. Standard water heaters will adhere to the following requirements:

2.5.1.1. Water heaters will be glass lined storage type.

2.5.1.2. Gas water heaters will have an automatic gas shut-off device and will be equipped with an American Gas Association certified draft hood. Water heaters will utilize electric ignition devices.

2.5.1.3. Electric water heaters will be Underwriters' Laboratories, Inc. (UL) listed.

2.5.1.4. All standard water heaters will have a 10- year limited warranty.

2.5.1.5. All energy saver water heaters will meet the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards for Energy Efficiencies, latest edition.

- 2.5.1.6. Water heater drains will have valves and will be plumbed to a floor drain with copper piping.
- 2.5.1.7. All water heaters will be readily accessible.

2.6. Plumbing Fixtures and Accessories

- 2.6.1.** All plumbing and fixtures at the Terminals must be in-line with the latest HAS Restroom Design Guidelines. All exposed metal work at fixtures will be brass with chromium plate. All faucets, fittings, supply stops for fixtures, and similar devices will be furnished from a single manufacturer unless otherwise required. Each fixture will contain standardized interchangeable operating units made up of separate renewable stem, seat, washer retainer, and nut. All faucets and fittings must close with the water pressure. All fixtures will be installed with supply stops/valves accessible at the fixtures. All fixtures will be approved by the Designer.
- 2.6.2.** All fixtures and accessories listed apply to HAS owned, operated, or maintained buildings. Some fixture and accessory preferences may change over time depending upon current maintenance warehouse stocking. Tenants may have different preferences and will be consulted.
 - 2.6.2.1. All specified fixtures must meet accessibility requirements.
- 2.6.3.** On renovation projects, an effort will be made to match existing fixtures and trim. On renovation projects where fixtures and trim cannot be matched and on new projects, fixtures will be WaterSense labeled American Standard or an approved equal.
- 2.6.4. Water Closets:** Wall-hung water closets are preferred. Water closets will be white, vitreous china, siphon jet, elongated bowl, with white open-front seat without a cover.
- 2.6.5.** Flush valves for water closets in Terminal facilities will be as follows:
 - 2.6.5.1. Toto self-energizing flush valves, TET1LA or similar Toto product.
 - 2.6.5.2. Concealed rough brass hydraulically operated flush valve, 1-inch wheel handle back-check stops, adjustable tailpiece, solenoid motor operator, sensor, vacuum breaker, elbow flush connection, and spud coupling for 1½-inch concealed back spud.
 - 2.6.5.3. Automatic sensor for operation of each water closet, with required transformers, controls and complete wiring diagrams for separate operation in each toilet; and as recommended and approved by flush valve manufacturers.
 - 2.6.5.4. Flush valves, as described above, are approved or an approved equal may be used.
 - 2.6.5.5. Flush valves in other facilities will be Toto self-energizing flush valves, TET1LA or similar Toto product, wall mounted flush valves.
- 2.6.6. Urinals:** Wall-hung urinals are preferred. Urinals will be white, vitreous china, wash-out type. Flush valves for urinals in Terminal facilities will be as follows:
 - 2.6.6.1. Toto self-energizing flush valves, TET1LA or similar Toto product.
 - 2.6.6.2. Concealed rough brass hydraulically operated flush valve, ¾-inch wheel handle back-check stops, adjustable tailpiece, solenoid motor operator, sensor, vacuum breaker, elbow flush connection and coupling for ¾-inch concealed back spud, wall and spud flanges for each urinal.
 - 2.6.6.3. Automatic sensor for operation of each urinal with required transformers, controls and complete wiring diagrams for separate operation in each toilet; and as recommended and approved by flush valve manufacturers.
 - 2.6.6.4. Flush valves, as described above, are approved or an approved equal may be used.
 - 2.6.6.5. Flush valves in other facilities will be Toto self-energizing flush valves, TETIGNG-32, or similar Toto product, wall mounted flush valves.
- 2.6.7. Lavatories:** Wall-hung, white enameled, cast iron, or white enameled cast iron self-rimming lavatories with 20-inches by 18-inches rectangular basin with splash back are preferred. Faucets will be Kohler brand, or approved equivalent, self-closing adjustable from 5 to 15 seconds.

- 2.6.8. Electric Water Coolers (EWCs):** Wall hung Elkay with bottle fillers, or equivalent electric water coolers, are preferred. EWCs will meet accessibility requirements. Some Terminal facilities may have a central water-cooling system. The Designer will investigate the possibility of connecting to this system where it is available.
- 2.6.9. Service Sinks:** Service sinks will be white enameled cast iron, 20 inches by 22 inches, blank back with wall hanger supports. Faucets will be a Kohler brand, or equivalent, wall-mounted rough plated faucet with valve units, vacuum breaker, wall brace, and threaded spout with pail hook. Trap will be adjustable standard for 3-inch pipe connection with cleanout plug and strainer, enameled inside. Rim guard will be 9 inches and 12 inches stainless-steel rim guard, front and sides.
- 2.6.10.** Mop basins will be a one-piece mop service basin, size 24 inches by 12 inches high outside, with Type 304 stainless-steel, 20-gauge cap, continuous on all sides, with wall flashing on back and sides as required. Provide silicone base for full seal at floor and grout the entire installation level. Service faucet will be chrome plated with vacuum breaker, integral stops, adjustable wall brace, pail hook, 3/4-inch hose thread on spout, and 8-inch spread. Hose and hose bracket will be 30-inches long, flexible, heavy-duty with 3/4-inch rubber hose, cloth reinforced, with 3/4-inch chrome coupling at one end. Five-inch-long bracket by 3 inches wide, with rubber grip. Mop hanger will be 24 inches long by 3 inches wide, 18-gauge No. 302 stainless-steel attached with flat head and slotted machine screws.

2.7. Backflow Preventers

- 2.7.1. Backflow Preventers:** A backflow preventer will be installed where the service line provides potable water for domestic water service and connects with other closed or chemically treated systems that could foreseeable contaminate the potable water line. Drains off the backflow preventer assembly will be drained to the sanitary sewer. Taps to mains, to provide water for fire protection or other closed pipe systems, will have a double check valve assembly at the fire line tap. An alternate method of backflow prevention consists of a 12-inch air gap between an unrestricted overflow of an atmospheric makeup tank and the source of water is also acceptable. All double check and reduced pressure backflow preventers must be certified for operation after installation by a Texas Commission on Environmental Quality (TCEQ) certified tester.
- 2.7.2. Reduced Pressure Backflow Preventers:** All pressure reducing backflow preventers that are installed to protect high-hazard services from back flowing, must be tested annually from the date they are installed and certified.
- 2.7.3.** Provide a double check backflow preventer when domestic service is connected to the service water main. A backflow preventer will be installed on any domestic water line serving other closed or chemically treated systems that could foreseeable contaminate the potable water line. All backflow preventers will be installed in a readily accessible location, no more than 4 feet above the floor.
- 2.7.4. Temporary Water Service (Backflow Preventer):** All temporary construction water services will be provided with a line sized backflow preventer, double check valve assembly. Services will not be initiated until backflow prevention devices have been approved by the HAS Project Manager.

2.8. Emergency Eyewash and Safety Shower

- 2.8.1.** Emergency eyewash and safety showers will be installed at apron level near every fuel shut-off switch (EFSO). Emergency showers and eyewash stations will conform to ISEA Z358.1 tempered water. Waste connections will not be required for emergency showers and eyewash.

2.9. Function

- 2.9.1.** The piping system design will include lateral bracing with pipe hangers and supports to prevent swaying.

- 2.9.2.** Pipe sleeves will be provided for all pipes passing through masonry and concrete construction.
- 2.9.3.** The annular space between pipes and sleeves must be permanently sealed, and sleeves below grade must be watertight.
- 2.9.4.** Pipe joints must not be made closer than 12 inches to a wall, ceiling, or floor penetration, unless such pipe is welded.

2.10. Flexibility

- 2.10.1.** As noted in Part 1 of this Standard, the Designer will consider the latest technology in designing the plumbing systems. Considerations are inclusive, but not limited to, off peak conditions, power consumption, and energy conservation. The Designer will also consider future expansion and growth as applicable to each project.

2.11. Serviceability

- 2.11.1.** Maintainability will be considered in all equipment layouts. Adequate spaces and clearances, as prescribed in relevant standards and as per the manufacturer, will be considered.
- 2.11.2.** All floor drains must be readily accessible.
- 2.11.3.** All water heaters must be readily accessible.
- 2.11.4.** Electric water heaters, located in ceiling/ attic spaces, will be accessible through an access door or by removing ceiling tiles. No asbestos containing material (ACM) will be used.
- 2.11.5.** Make provisions for dispersion of chemical treatment for public banks of urinals.

2.12. Sustainability

- 2.12.1.** The Designer will employ sustainable strategies that, in aggregate, use a minimum of 25 percent less water than the water usage baseline calculated using the following table. Additionally, all newly installed toilets, urinals, private lavatory faucets, and shower heads that are eligible for labeling must be WaterSense labeled.

Commercial Fixtures, Fittings, and Appliances	Current Baseline
Water Closets (Toilets*)	1.28 gallons per flush (gpf)
Urinal*	1.0 gpf
Public Lavatory (restroom) Faucet	0.25 gpm at 60 psi all others except private applications
Private Lavatory Faucet*	2.2 gpm at 60 psi.
Kitchen Faucet (excluding faucets used exclusively for filling operations)	2.2 gpm at 60 psi

Shower Head*	2.5 gpm at 80 psi per shower stall
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*WaterSense label available for this product type

- 2.12.2.** The Designer will consider using such techniques as controlling hot water temperatures and water pressures and providing faucets with flow restrictors. To provide maximum energy efficiency, the system must consider the following measures: economic use of thermal insulation, automatic shutdown of water heating and circulating systems, use of waste heat from HVAC systems, use of off-peak power, occupancy sensors for automatic flushing, use of automatic closing faucets, and use of minimum energy consuming equipment.
- 2.12.3.** All energy saver water heaters will meet the ASHRAE Standards for Energy Efficiencies, latest edition.
- 2.12.4.** The design, fabrication, and construction will be coordinated with HAS regarding the following:
- 2.12.5.** Airport Cooperative Research Programs (ACRP) Synthesis 10; Sustainability Practices that explore environmental, economic, and social issues.
 - 2.12.5.1. The Transportation and Research Board (TRB) ACRP Synthesis 21:** Airport Energy Efficiency and Cost Reduction explores energy efficiency improvements being implemented at airports across the country that are low cost and short payback.
 - 2.12.5.2. TRB’s ACRP Report 42:** Sustainable Airport Construction Practices explore a set of best practices, methods, procedures, and materials that if implemented during construction may have a sustainable, positive economic, operational, environmental, or social effect.
 - 2.12.5.3. Non-public Areas:** Non-public restrooms, janitor closets, equipment rooms, storage rooms (applicable as discussed with HAS) and pet areas will be designed with hose bibs.

Part 3 – Execution

3.1. Installation

- 3.1.1.** All piping in buildings will be identified using pipe marker bands, with direction of flow arrows, at 10-foot intervals in concealed spaces; 20-foot intervals in exposed areas and on each side of any penetrated wall, ceiling, or floor. Pipe marker color coding will follow industry practice ANSI/ American Society of Mechanical Engineers (ASME) A13.1, *Scheme for Identification of Piping Systems*.
- 3.1.2.** 50-50 solder will not be used for any pipe jointing. When applicable, lead free solder or press fittings will be used provided that manufacturer’s recommendations are followed. Press fittings will not be used in mechanical rooms close to pumps where there can be excessive vibration. No direct buried copper piping will be permitted inside or outside facilities. The use of ferrous metal pipe and fittings under slabs will be reviewed on a case-by- case basis but generally discouraged.
- 3.1.3. Hangers and Supports:** All pipes must be adequately supported throughout. Generally, hangers will be split ring or clevis type; however, trapeze hangers, constructed of steel channels with welded spacers and steel rods, may be used. All hangers and supports will comply with MSS Standards. Vertical pipes must be supported at each floor with pipe clamps.
- 3.1.4.** Provide pipe saddles fabricated from galvanized metal, for insulated pipe, extending at least 12 inches in length and covering a minimum of a half-pipe circumference. Generally, the gauge will be as follows:
 - Pipe Diameter USS Gauge Up to 3 inches - No. 22
 - Three through 6 inches - No. 16
 - Above 6 inches - No. 12

3.2. Testing

- 3.2.1.** All tests will comply with certification agencies' standards and practices. Details regarding testing procedures will be approved by the HAS Project Manager, and test results must be witnessed and verified by HAS.

3.3. Training

- 3.3.1.** Operations and maintenance manuals for all equipment will be a project deliverable provided by the Contractor and will contain applicable information facilitating the operation and maintenance of relevant equipment.

26 - HEATING, VENTILATION AND AIR CONDITIONING (HVAC)



26 - Heating, Ventilation and Air-Conditioning (HVAC)

Part 1 – General

1.1. Introduction

- 1.1.1. The intent of the Houston Airport System (HAS) heating, ventilation and air-conditioning (HVAC) design criteria is to establish a baseline set of criteria for HVAC systems anywhere in the airport system that coordinate and augment the criteria used by the City of Houston (COH). This Standard defines general design criteria that apply to HVAC systems at HAS facilities as well as those HVAC systems served by the various Central Utilities Plants (CUP). Mechanical system design will consider, construction, commissioning and operation phases of the building life cycle.
- 1.1.2. The Designer is responsible to verify the locations and/or the adequacy of record information prior to design and construction of HVAC systems. The Designer will coordinate the development of the design at all stages with HAS.
- 1.1.3. All areas used primarily to accommodate people-oriented activities such as offices, concessions, concourses, cafeterias, etc., will be air conditioned and heated. Areas classified as storage or manufacturing will be mechanically ventilated and heated to meet the minimum requirements of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62.1-2010. The criteria for a HVAC system will vary somewhat from building type to building type, or project to project, which may change certain parameters of initial design considerations.
- 1.1.4. System design for new terminal facilities must conform to the basic design parameters, equipment, and material criteria described herein. Heat pumps, roof top units, and plenum-mounted condensing units, plenum return systems are not desired and require approval from HAS.
- 1.1.5. Restrooms will have an air exchange rate of 20 air changes per hour (ACH) or at a rate depicted at Design Guidelines. Designer will consider air change rates that accommodate door-less entries for public restrooms in terminals. Please also check HAS Restroom Design Guidelines for more and current information.
- 1.1.6. Mechanical noise levels will be controlled by proper design of the noise producing mechanical and electrical equipment such as fans, terminal units, diffusers, pumps, transformers, emergency generators, etc., to not exceed acceptable levels as set forth by industry standard criteria. The acceptable noise level will be described in terms of Noise Criteria as defined by the ASHRAE Handbook, Systems Volume (Sound and Vibration Control Chapter, latest edition).
- 1.1.7. **All Design:** Architectural and Mechanical, Electrical, and Plumbing (MEP) discipline design must be integrated and coordinated.
- 1.1.8. The BAS will integrate and monitor all building mechanical and plumbing systems. This includes control and monitoring of the HVAC system; domestic water distribution (including sub-metering); system pressures; space and system temperature and flow rates for HVAC chilled and heating water systems; and lift stations. New facilities will have complete direct digital control (DDC) system.
- 1.1.9. For design purposes of new connections to the secondary loop, supply and return pressures must be obtained from the CUP Utilities Manager. Facilities requiring greater than the value provided will require booster pumps for the chilled water system.
- 1.1.10. For buildings other than terminal facilities, use HAS/stakeholder recommendations as guides in

selecting the type of HVAC system for these buildings when not served by the CUP. In many instances, direct expansion packaged systems are satisfactory. When packaged systems are used, the control system supplied by the manufacturer is acceptable; however, controls must be compatible and interact with the building automation system (BAS). Thermostatic zoning must not be compromised when using packaged equipment. Sustainability and green design encouraged to reduce load at the grid.

- 1.1.11. Chilled & Hot Water from the CUP:** Design for additional facilities attached to these systems must consider existing plant pressures, capacities and supply return temperatures. Modifications to the plant capacity and or pumping system must be included in the design to maintain necessary flow rates to existing facilities.
- 1.1.12.** “Stand-by” pumps are required for facilities, especially for facilities containing computer rooms.
- 1.1.13.** Pumps that are connected to the CUP chilled and hot water loops must be outfitted with suction and discharge pressure transmitters and flow meters that will tie into the respective control system. The control system must interface with the pump controls in order to provide full control and visibility of the pump operation.
- 1.1.14.** The terminal facilities will be served by air handling units (AHU) with fan powered VAV terminal units and hot water or electric heating when applicable.
- 1.1.15.** Heat exchangers will be of shell and U-tube type utilizing high temperature hot water (HTHW) in accordance with American Society of Mechanical Engineers (ASME) Code for Unified Pressure Vessels. Present operating pressures will be verified with HAS. Units will be provided with vent, water inlet and outlet, and other connections as required.

1.2. Quality Assurance

- 1.2.1.** Design considerations will also include the involvement of HAS Infrastructure, operations and maintenance, and electric shops staff. Stakeholder involvement during design charrettes is key to the Quality Assurance Program.
- 1.2.2.** Quality design will achieve internal environmental quality and thermal comfort balance. The Basis of Design is the latest International Building Code (IBC), as amended by the COH, and the latest Uniform Mechanical Code (UMC), as amended by the COH and the Houston Commercial Energy Conservation Code. Applicable codes and the project Basis of Design establish the minimum requirements. The Contractor will verify local code compliance with the Authority Having Jurisdiction.
- 1.2.3.** The balancing, testing, and adjusting of HVAC systems will be performed by an independent technical firm or balancing agency not involved in the design. The balancing firm will be Associated Air Balance Council or National Environmental Balancing Bureau certified. All tests will comply with certification agencies standards and practices.
- 1.2.4.** A pipe stress analysis will be performed to ensure the system has adequate flexibility and to determine support, equipment reaction forces, and support spacing. Expansion loops and/or expansion joints will be provided where necessary to limit pipe stress or reaction forces in accordance with the applicable ASME B31 piping code. Where possible, the use of engineered expansion loops is preferred to expansion joints.
- 1.2.5. Heating:** The winter indoor comfort design temperature will be 72°F dry-bulb (DB), unless otherwise indicated. Humidification is not required except for special purpose facilities.
- 1.2.6. Cooling:** Summer indoor comfort design temperature will be 75°F DB, unless otherwise indicated. The design relative humidity will be 50 percent. Cooling coils will be designed so the building annual relative humidity (RH) range will not exceed 60 percent RH. Face and by-pass coils must be used on all VAV systems to prevent high humidity conditions during partial load (i.e., control supply air temperature with face and by-pass). The use of face and by-pass coils

may be reviewed on a case-by-case basis.

1.2.7. Outdoor Design Temperatures: Summer – 98°F DB, 80°F WB Winter – 20°F DB.

These climatic temperatures represent temperatures used in calculations when designing relevant systems.

1.3. Shop Drawings and Submittals

1.3.1. Submittals will be prepared in accordance with Division 1 Specifications and the Designer's technical specifications.

1.3.2. A clear sequence of operations will be provided by the Designer in the construction documents. The record documents will reflect changes made during construction and start-up tests.

1.4. Warranty

1.4.1. Warranties will be as provided below. Consult with HAS if additional warranties are beneficial for the specific project.

Part 2 – Products

2.1. Information

2.1.1. MEP formed and or fabricated materials, except devices and equipment, will be produced and shipped within a 500-mile range of HAS facilities.

2.1.2. All curb-mounted units will be furnished with appropriate enclosed engineered curbs to provide for level unit mounting with a minimum 16-inch curb height above the top of the roof deck surface.

2.1.3. The Designer's MEP Engineer will synchronize panel load distribution with the mechanical equipment and location. Designs with one side loaded electrical panels are not acceptable.

2.1.4. Variable Frequency Drives (VFD): Ultra low harmonics.

2.1.5. If available, natural gas is preferred as a source of heating.

2.1.6. BAS: as noted in Part 1 of this Standard.

2.1.7. Heat pumps, roof top units, and plenum mounted condensing units are not allowed in terminal facilities.

2.1.8. No recycled content will be allowed for MEP equipment.

2.1.9. Water hammer arrestors, air duct acoustic silencers, vibration sound mufflers, etc., may be included in the design. Design must decrease reverberations to make it more hearing friendly. Sone/NC levels will be as per ASHRAE or as agreed to by the Designer.

2.1.10. Coil Valves: Control valves will be pressure independent control valve (PICV) two-way control valves. Use of three-way chilled water valves are prohibited.

2.2. Insulation

2.2.1. Pump Insulation: Chilled and hot water pumps will be insulated with flexible elastomeric cellular

insulation. Insulation will terminate at unions, flanges, etc. for maintenance purposes, in a neat sealing manner, with pump bed plate section designed to drain all moisture.

- 2.2.2. Internal Duct:** Generally, all ductwork except exhaust ductwork will be externally insulated in accordance with temperatures involved, the current International Energy Conservation Code (IECC), and International Fire Code. Ductwork insulation materials will be selected for the function involved, considering sound absorption coefficients, velocities, etc. Particular attention will be given to the first 20 feet of duct mounted on the supply (discharge) side of AHUs. The Designer will utilize double walled, perforated duct for sound absorption if required.
- 2.2.3.** External duct, low velocity wrap may be used where insulation is not exposed to abuse. Where insulation may be subject to abuse, insulation will be 2-inch thick, 3-pound density glass fiber with rigid board duct insulation, and complete with reinforced foil-kraft integral heavy vapor proof covering on the outside surface. Insulation will have a minimum compressive strength of 140 pounds per square foot at 10 percent deformation. Securely fasten all edges, joints, etc., to provide a vapor proof duct. Rigid insulation will be mechanically fastened to the duct.
- 2.2.4. External Duct High Velocity:** Generally, high velocity ductwork requiring external insulation will be insulated with blanket wrap fiberglass insulation, 1-½ inch thick at 1 pound density or minimum thermal resistance of 6.0, complete with a scrim kraft jacket. Facing overlapping joints will be at least 2 inches and held in place with outward clinching staples on approximately 4-inch centers. Underside of ducts exceeding 24 inches wide or 24 inches in diameter will be mechanically fastened.
- 2.2.5.** High velocity, flexible duct, will be Underwriter's Laboratories, Inc. (UL) 181, Class I, with a rating to meet or exceed the National Fire Protection Association (NFPA) 90A-90B and reinforced with a perforated sheet metal inner jacket.
- 2.2.6.** All piping and vessels with a surface temperature less than ambient temperature, will have a vapor barrier covering. The vapor seal will be continuous, unbroken, and adhere to the surface so that the insulation is airtight in order to minimize the possibility of vapor draining into the insulation material.
- 2.2.7.** Form fitted polyurethane insulation will be used on all coil header piping to the extent necessary to include all valves, including flow control valves, and other appurtenances utilized to evaluate the performance of the coil.
- 2.2.8. Chilled Water Pipe Insulation:** Chilled water pipes that are supplied from Central Utility Plant will be insulated with 2-inch-thick insulation. ASHRAE Standards will be followed if the results in greater thickness. Outdoor and unconditioned indoors will be cellular glass and metal cladding. Jacket laps and butt strips must be adhered with vapor barrier adhesive or position sealing system. Tee fittings are not allowed due to bull head pressure. Insulate all fittings and valves using preformed fitting insulation of same material, density, and thickness as used for adjacent pipe.
- 2.2.9.** Galvanized steel saddles, 16 gauge – 18 inches long, will be installed at all pipe supports to protect the insulation. Higher density insulating materials must be used at pipe supports, if required to prevent crushing/cutting of insulation. All exterior exposed pipes will have aluminum metal jacket as specified below.
- 2.2.10.** All exterior exposed pipes will have aluminum metal jacket as described below. Direct buried chilled water piping can be pre-insulated with 2-inch thick urethane foam. Joints will be piston-ring, internally guided, double-expansion joint, or a pack less expansion joint
- 2.2.10.1.** Hot Water Piping: Follow description above for chilled water piping, except, that vapor barrier is required on direct buried pipe only.
- 2.2.10.2.** Condensate drain, refrigeration suction, and chilled water piping 2 inches and smaller, follow the description above for chilled water piping. Acceptable thickness will be 1 inch.
- 2.2.10.3.** All chilled water and hot water piping, in tunnels or exposed to the outdoors, will have a smooth finish aluminum metal jacket. It may also have a small rib texture aluminum metal

jacket on calcium silicate. The minimum jacket thickness will be .016 inch.

- 2.2.11.** Chilled and hot water pumps will be insulated. Provide removable insulated enclosure over pump casing to facilitate pump maintenance.

2.3. Pipe Material

- 2.3.1.** Hot and chilled water piping inside buildings will be welded.
- 2.3.2.** Expansion joints will provide 200 percent absorption capacity of piping expansion between anchors. All chilled and hot water piping joints will be welded; therefore, special consideration must be given to pipe layout for expansion and contraction.
- 2.3.3.** Vertical pipes must be supported at each floor with pipe clamps.
- 2.3.4.** Pipe saddles will be galvanized metal (for insulated pipe) extending at least 12 inches in length and covering a minimum of a half- pipe circumference. Protection shields must be provided for all insulated pipe, unless noted otherwise.
- 2.3.5.** Underground hot and chilled water piping is not allowed without the approval of HAS.
- 2.3.6.** Refrigerant piping will be Type Air- Conditioning and Refrigeration (ARC) copper, capped and cleaned. Joints will be purged with nitrogen.

2.4. Pumps

- 2.4.1.** Impellers will be one piece, hydraulically and statically balanced, and keyed to the shaft. Impeller size will not be more than 90 percent of the maximum impeller size allowed for the pump casing.
- 2.4.2.** Pump and motor bearings will be grease lubricated.
- 2.4.3.** Provide variable volume pumping systems with variable frequency electric drives with Ultra-low harmonics.
- 2.4.4.** Provide pressure gauge taps with stop cocks and gauges on suction and discharge sides of the pump. Provide thermometer wells on suction and discharge sides of pumps.
- 2.4.4.1.** Horizontal split case pumps will be constructed so that removal of pump shaft impeller, seal, bearings, etc., may be possible without the removal of the pump casing from the line, or disconnecting either suction or discharge connection.
- 2.4.4.2.** Motors will be American National Standards Institute/National Electric Manufacturers Association (ANSI/NEMA) Premium efficiency.
- 2.4.4.3.** Chilled water and hot water pumps will be arranged with suction and discharge headers to allow use of any pump with any chiller, cooling tower etc., as applicable.
- 2.4.4.4.** Mechanical seal assembly will have replaceable seats.
- 2.4.4.5.** Connection will be flanged or union connection (type depending on size, pipe, and work space restrictions).

2.5. Ductwork

- 2.5.1.** All ductwork systems will be constructed and installed in accordance with Sheet Metal & Air-Conditioning Contractor's National Association (SMACNA) and ASHRAE guidelines, specifically SMACNA's *"HVAC Duct Construction Standards – Metal and Flexible Ducts"*. For all AHUs,

ductwork pressure class will be medium class constructed to 4-inch water gauge (w.g.) (minimum) seal class will be Class A. Any variable air volume system duct of 1 inch (250 Pa) and 1/2-inch w.g. (125 Pa) construction class that is upstream of terminal units will meet Seal Class B.

- 2.5.2.** Ductwork material will be zinc-coated sheet steel of the thickness of the metal and stiffeners as indicated in the SMACNA Manual. The seams will be sealed per SMACNA's Standard Duct Sealing Requirements.
- 2.5.3.** All ductwork will be insulated. Airflow measuring stations accompanied with temperature sensors will be installed and interfaced to the Building Management System wherever a branch of ductwork handles 10 percent of the total cubic feet per minute (cfm) of the dedicated AHU.
- 2.5.4.** All ductwork installed below the floor in crawl spaces or below grade will be constructed with watertight joints and will be tested and proved tight before floors are poured. Underfloor duct systems may be constructed of fiberglass, polyvinyl chloride (PVC) or other approved non-metallic material.
- 2.5.5.** All variable volume terminal units will be equipped with at least a five-diameter length of straight rigid duct immediately upstream of the volume control devices.
- 2.5.6.** All discharge ductwork will have acoustical lining inside the ductwork for minimum of 15 feet or past first 90-degree elbow on downstream side of AHU.
- 2.5.7.** Flexible ductwork will comply with UL 181 Class 1 and will meet or exceed NFPA 90A-90B rating. Maximum length of flexible duct will be 5 feet. All diffusers in terminals will have dampened insulated boxes with minimum box height of 1 foot.
- 2.5.8.** Ductwork will be leak tested as per SMACNA guidelines.
- 2.5.9.** Wherever ductwork is connected to fans, AHUs, or other equipment that may cause vibration in the ductwork, the connection to the equipment will be by a flexible connection constructed of fire-resistant flexible canvas or other approved material. The connection will be suitable for the pressures at the point of installation.
- 2.5.10.** Maximum length of flexible ductwork will be 5 feet.
- 2.5.11.** All flexible ductwork connections to grilles and air devices will have a radius forming brace installed at the connection.
- 2.5.12.** All kitchen duct will be fabricated and installed per SMACNA. All Hoods (UL), ventilation (make-up air), supports and fire suppression will be compatible to relevant processes within the kitchen. Exhaust ducts will be sloped toward the hood to prevent grease accumulation.

2.6. Air Handling Units (AHUs)

- 2.6.1.** Provide a hand operated "auto/on/off" switch and remote-control terminations at each air handling unit location with properly sized integral heaters. Also provide a fused disconnect switch at each location. AHU fans that provide more than 5,000 cfm of air will be AHRI certified semi-custom watertight and airtight units and will have fan array system with a separate VFD for each fan. There will be no condensation forming on the unit exterior and units will be provided with backdraft dampers to prevent short circuits.
 - 2.6.1.1.** Provide stainless-steel drain pan, insulated, sloped in two or more planes to eliminate stagnant water with a drain line no less than 3/4-inch in diameter or size of tap on drain pan. Use a plugged tee for all changes in direction rather than a 90-degree ell. Condensation will be drained to the sanitary sewer.
 - 2.6.1.2.** AHU casings will be double-wall construction, galvanized steel rigid with minimum 2-inch thick injected closed cell foam insulation between the walls. The casing design will have no-thru-

metal in the roof, walls, floor and doors. Under no circumstances will it be acceptable to pressure drop across the filter. Filters will be 2-inch thick throwaway, efficient, pleated type contained in rigid media frame with supporting maze across leaving face of media. Two-inch filters will be used in equipment below 5,000 cfm.

- 2.6.1.3. Medium efficiency filter design is – 500 foot/min, 0.28-inch w.g. initial resistance, MERV - 13.
- 2.6.1.4. High efficiency filter design is – 500 foot/ min, 0.68-inch w.g. initial resistance, MERV–14. Generally, space conditioning filters will be 2-inch-thick with dimensions of 20 inches by 20 inches, 20 inches by 25 inches, 16 inches by 20 inches or 16 inches by 25 inches preferred.
- 2.6.2. Electric motor speeds in excess of 1,800 revolutions per minute (rpm) are discouraged. Fans will be selected for the highest efficiency and airfoil type is preferred. Motors will be ANSI/NEMA MG 1.
- 2.6.3. Custom outdoor AHUs will provide pre- conditioned make-up air to applicable HVAC systems throughout terminal facilities. Units must have, pre-filters, air purifier, high efficiency filter, hot water coil (pre-treat), chilled water coil, VFD controlled have insulating materials exposed to the air stream. AHUs will meet ASHRAE 111fan, CO interior monitor and control, stainless-steel, and the factory will provide units Casing Air Leakage Rating Class: CL6 and Casing Deflection Rating Class: CD2. AHUs will have factory mounted and tested controls, end devices with generic input and output signals.
 - 2.6.3.1. Coil casing stainless-steel: Fans – spring mounted fan drives² with internal flexible connection on fan discharge. Use of belts is discouraged for motor-fan interface. Bearings – 200,000 hours at maximum horsepower and speed, grease lubricated pillow block bearings with grease fittings accessible from outside the unit. Bearing will be protected from induced currents.
 - 2.6.3.2. Air handling equipment must be equipped with filters as per ASHRAE 52.2. High efficiency filters will be provided on equipment over 5,000 cfm, medium efficiency filters on less than 5,000 cfm. Filters are to be provided with magnahelic gauges (alarmed) that will measure liner with mounted test ports. Casing Air Leakage Rating Class: CL6 Casing Deflection Rating Class: CD2. The units will also have the following:
 - 2.6.3.3. Pre filters - medium efficiency pleated
 - 2.6.3.4. Air purification systems will be capable of Controlling microorganisms such as mold, bacteria, vapors, and other airborne particulates.
 - 2.6.3.5. Controlling gas phase contaminants including volatile organic compounds (VOCs) found in airport applications such as the following:
 - Jet and automotive exhaust
 - Tri-cresyl phosphates
 - Aldehydes
 - Acetic acid
 - Carbon monoxide
 - Sulfur oxides
 - VOCs
 - Bio effluents
 - Acetaldehyde
 - Acetic acid

- Acetone
- Allyl alcohol
- Ammonia
- Amyl alcohol
- Butyric acid
- Diethyl ketone
- Ethyl acetate
- Ethyl alcohol
- Formaldehyde
- Methyl alcohol
- Hydrogen sulfide
- Methane
- Methyl alcohol
- Phenol
- Toluene

- 2.6.3.6.** Reducing static space charges. Complies with UFC 4-010-01 (8 October 2003 including change 1, 22 January 2007) Standard 18. Emergency Air Distribution Shutoff for Antiterrorism Force Protection.
- 2.6.3.7.** As tested by the Department of the Army, U.S. Army Dugway Proving Ground, Dugway, UT in conjunction with minimum MERV 13 rated filtration, the photocatalytic oxidation system must be able to remove or neutralize better than 98 percent of airborne bacterial spores. The entire assembly will bear the UL Classification Mark and be investigated in accordance with ANSI/UL 1598, "*Luminaires*," and ANSI/UL 1995, "*Heating and Cooling Equipment*," under the Air Duct Mounted Accessories category (ABQK). Compliance is to be verified by the UL Online Certifications Directory.
- 2.6.3.8.** Chilled water and hot water coils will be continuous copper tube type with copper or aluminum fins.
- 2.6.3.9.** Access covers to water coils on the AHU housing will be readily removed for access to coil headers without piping disconnects or demolition of surrounding structures.
- 2.6.3.10.** Cooling coil design will be based on the criteria described in this Standard.
- 2.6.4.** Rooftop systems will be completely self-contained, with factory wired controls, and factory assembled components and piping. Equipment will have 2-inch-thick pleated replaceable media filters. Compressors must have a 5-year warranty, including parts and labor (5 tons and under). All curb-mounted units will be furnished with appropriate enclosed engineered curbs to provide for level unit mounting with minimum 16-inch curb height above top of the roof deck surface. An alternative is a structural steel support frame with a minimum of 40-inch clearance above finished roof. All rooftop systems require approval from HAS and are generally discouraged.
- 2.6.5.** Split systems will consist of furnace, coiling section plenum with direct expansion cooling coil, air-cooled condensing unit or heat pump, piping, controls, etc. All components will be factory wired and assembled. Furnaces will have filter racks complete with a 1-inch-thick throw-away filter. Compressors will have a 5-year warranty, including parts and labor (5 tons and under).
- 2.6.6.** Split system air conditioners must have a Seasonal Energy Efficiency Ratio (SEER) rating of 16

or it must meet the latest version of the IECC requirement, whichever is greater. Split system air conditioners generally discouraged.

- 2.6.7.** Fan-Coil Units (FCUs) will have a high, medium, low, and off switch where adjustments can be made without removal of the access door or unit housing. This switch will be easily accessible for room or area occupant’s personal adjustments. FCUs will be double-wall construction as described for modular indoor AHUs. For MDF, IDF and other applicable rooms requiring redundant AHU’s or computer room air-conditioning (CRAC) units the designer will consider using split system direct expansion systems for redundancy. The system controls will account for periodic start / stop of said unit (refer to specification 271100-11 “Communications cabinets and equipment rooms”). FCUs generally discouraged.
- 2.6.8.** FCUs will be equipped with replaceable pleated filters. A minimum of MERV 7 should be used but where the static pressure requirements allow higher MERV values up to MERV 13 should be attempted.
- 2.6.9.** The use of FCUs will be limited to sizes below 2,000 cfm and require prior approval from HAS.

2.7. Cooling Towers

- 2.7.1.** For cooling towers and evaporative condensers, conduct a one-time potable water analysis, in order to optimize cooling tower cycles. Measure at least the five control parameters listed in the table below.

Parameter	Maximum Level
Ca (CaCO3)	1,000 ppm
Total alkalinity	1,000 ppm
SiO2	100 ppm
Cl	250 ppm
Conductivity	2,000 us/cm

Calculate the number of cooling tower cycles by dividing the maximum allowed concentration level of each parameter by the actual concentration level of each parameter found in the potable makeup water. limit cooling tower cycles to avoid exceeding maximum values for any of these parameters. Achieve a minimum 10 cycles by increasing the level of treatment in condenser or make-up water and use a minimum 20 percent recycled non-potable water. Legionella disease prevention steps and maintenance plan will be submitted to HAS.

2.8. Coils

- 2.8.1.** Chilled water and hot water coils will be of the continuous copper tube type with copper or aluminum fins. Tubes will be counter flow with side coils into casing through removable panels and blank off sheets, maximum water velocity of 8 feet/second and either 1/2-inch or 5/8-inch outside diameter tubes, 12 fins/inch with copper headers, 1/2-inch tube thickness – 0.020 inch, 5/8-inch tube thickness 0.025 inch. Maximum airflow will not exceed 500 feet per minute. All coils will be cleanable and drainable. Each tube will be accessible without piping disconnect. Headers must be removable at the opposite end. All water coils will have maximum flow rate

control devices in the return line.

- 2.8.2.** Air Coil selection will comply with ARI 410, “*Standard for Forced-Circulation Air-Cooling and Heating Coils*”.
- 2.8.3.** Chilled Water-Cooling Coil entering water temperature should match existing conditions if demand is supplied from HAS CUPs
- 2.8.4.** Coil Water temperature rise – 16°F, unless noted otherwise.
- 2.8.5.** Maximum air face velocity – 500 feet per minute
- 2.8.6. High Temperature Water Heater (HTHW) Heating coil selection:**
 - 2.8.6.1.** Coil entering water temperature – should match existing conditions if demand is supplied from HAS CUPs.
 - 2.8.6.2.** Coil Water temperature drop – should match existing conditions if demand is supplied from HAS CUPs.
 - 2.8.6.3.** Maximum air face velocity – 500 feet per minute

2.9. Function

- 2.9.1. Meters and Gages for HVAC Piping:** Permanently installed british thermal unit (BTU) metering is required for all chilled and hot water applications served by the CUP. Metering must provide flow, temperature, and BTU per hour values to the respective energy management system. Meters must:
 - Record at intervals of one hour or less and transmit data to a remote location.
 - The system must be capable of storing all meter data for at least 36 months.
 - The data must be remotely accessible.
 - All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.
- 2.9.2.** All tenant facilities if met from HAS CUP will be metered using revenue-grade metering devices.
- 2.9.3.** Terminal facilities will be kept in positive pressure and will be monitored by magnehelic gauges using pressure differential sensors. These sensors will be in multiple strategic locations inside the building.
- 2.9.4.** At IAH, air pressure and velocity reading devices are required at each connection point to the Mickey Leland International Terminal (MLIT). Ambient as well as connections at terminals crossover and the subway tunnel and the garages. Said crossovers and the tunnel connect the MLIT to other Terminals A, B, C, E as well as the Federal Inspection Station (FIS) and the Marriott Hotel.
- 2.9.5.** At HOU, air pressure and velocity reading devices are required at each connection point to the International Terminal. Ambient as well as connections at terminals crossover and the garages.
- 2.9.6.** The designer will consider that animal retention areas/facilities will be designed and kept at a negative pressure. Dedicated mechanical systems will be considered where applicable.
- 2.9.7.** Terminal facilities will be designed in a way that pressurization is not lost when passengers use the boarding bridges. Boarding gate sensors will give signal to the VAVs and outside air unit sensors and amount of fresh air will be adjusted accordingly to prevent pressure loss.
- 2.9.8.** ASHRAE 62.1, ventilation requirements, will be exceeded by 30 percent at a minimum. Eliminating energy waste and parasitic heating will be a key design element.
- 2.9.9.** In terminal facilities, ceiling plenum return is not accepted unless there is an extension to an old system. Provide airtight ducted return system.

2.9.10. Rotating equipment redundancy, N number of pumps, fans etc.

2.9.9.1. If $N < 3 = N + 1$

2.9.9.2. If $N \geq 3 = N + 2$

2.9.10. Revenue metering will be provided at all tenant facilities for electricity, lighting, water, natural gas, chilled water (CHW) and heating hot water (HHW) flow, differential pressure, and differential temperature.

2.9.11. Install metering equipment enclosure in accordance with CenterPoint Energy guidelines.

2.9.12. All revenue meters will be smart meters where trending will be possible through a Supervisory Control and Data Acquisition (SCADA) if available and BAS. Meters must:

- Record at intervals of one hour or less and transmit data to a remote location.
- The system must be capable of storing all meter data for at least 36 months.
- The data must be remotely accessible.
- All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.

2.9.13. In addition to industry best practices and code requirements, the following key points will be included in the Sequence of Operations for HVAC controls:

2.9.13.1. Supply an air temperature and pressure reset schedule according to the outside air temperature.

2.9.13.2. System response to humidity conditions exceeding 60 percent relative humidity.

2.9.13.3. Nighttime and weekend setup/setback schedule will be patterned to match the building usage for both terminal units and AHUs.

2.9.13.4. Coordination of the use of return fans, such as turning the fan off when supply air pressure can be effectively maintained by the supply air fan only. Pumps should have Proportional Control on VFD setting.

2.9.13.5. Areas that require dedicated cooling support, such as data or communications rooms, must provide constant cooling (24/7/365).

2.9.14. Individual space control is desired for each totally enclosed office space or room. Individual terminal units, or a two-position damper, may be utilized with controls.

2.10. Flexibility

2.10.1. Baggage Handling System (BHS) equipment is usually an underestimated heat release source and results in complaints. A proper design coordinated with HAS is required at the occupied CBRA and operation areas.

2.10.2. Piping and ductwork risers must be considered and designed as headers for future expansion. Likewise, there must be allowances in the electrical power circuits.

2.10.3. For terminal facilities, the design must have flexibility to accommodate future expansion, inclusive of new retail, food and beverage concessions and restrooms.

2.10.4. Booster pumps for chilled and hot water systems will be controlled via tie-in to the CUP distributed control system via the BAS control system which gives Native BACnet signal to the HAS DDC. All requirements must be verified and approved by the BAS Administrator.

2.11. Serviceability

- 2.11.1.** At Terminal Buildings, avoid locating FCUs, VAVs and all air moving devices above ceilings of occupied spaces. This equipment must be in perimeter locations with sufficient accessibility. Terminal units located above finished ceilings will have adequate ceiling access panels or other means of access to the unit for maintenance and removal. Except for lift out ceiling installation, all access panels will be hinged.
- 2.11.2.** Equipment with proprietary service tools, which are not available to anyone other than the manufacturer, are not acceptable.
- 2.11.3.** Provide a fused disconnect for unitary equipment such as AHUs.
- 2.11.4.** Sensing bulbs and instruments will be accessible on mounted, vibration free supports.
- 2.11.5.** If needed, provide access to units by catwalks or decks.
- 2.11.6.** Adequate equipment rooms, shafts, ceiling spaces, and clear spaces around equipment will be allocated. Designer must specify easily accessible color-coded paint on visible equipment items. Free standing binnacle type, column type air ducts, or diffusers will be avoided. Equipment will be located beyond passenger's reach.
- 2.11.7.** Field lubricated ball bearing equipment is preferred over sleeve bearings. All air handling equipment will be selected and installed so that bearings can be replaced with minimum demolition of equipment or surrounding structures. Bearing lubrication points will be extended to a central external accessible point and fitted with alemite fittings.
- 2.11.8.** Access covers to water coils on the AHU housing will be readily removed for access without piping disconnect or demolition of surrounding structures.
- 2.11.9.** Provide hinged access doors with gaskets to AHU sections with view windows. Provide marine lights in each AHU section with timer-driven light switches on outside of unit.
- 2.11.10.** Chilled water and hot water control valves will be pressure independent with flanged or set in unions for easy removal.
- 2.11.11.** Engineered vibration isolation will be provided to prevent excessive noise or transmission of vibration to the building structure due to the operation of machinery or equipment, or due to interconnected piping, ductwork, or conduit.
- 2.11.12.** The vibration isolation system will consist of foundation, base, spring isolators, and rubber and shear pads as necessary to provide maximum isolation conforming to 2011 ASHRAE Handbook, HVAC Applications, Chapter 48 Table 1; AHRI Standard 885-2008, Table 15; or a local equivalent. Calculate or measure sound levels.

2.12. Sustainability

- 2.12.1.** Design will follow ASHRAE 90.1 "*Energy Standard for Building*", ASHRAE 62.1 "*Ventilation for Acceptable Indoor Air Quality*", ASHRAE 55 "*Thermal Comfort for Human Occupancy*", and Federal Aviation Administration (FAA) Design Standards. SMACNA Indoor Air Quality (IAQ) Guidelines for Occupied Buildings under Construction, 2nd edition ANSI/ SMACNA 008–2008, will be used for providing design and project management guidance in maintaining satisfactory IAQ of occupied buildings undergoing renovation or construction.
- 2.12.2.** Design of mechanical systems will allow sub-meters and data collection within the building.
- 2.12.3.** For unoccupied buildings after construction completion, prior to occupancy, and with all interior finishes installed, install new filtration media and, perform a building flush-out. This is performed by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot of floor area while maintaining an internal temperature of at least 60°F and no higher than 80°F

and relative humidity no higher than 60 percent.

- 2.12.4.** Equipment manufacturers must have a presence (manufacturer, distributor, sales office) and will have established service centers within the Houston city limits.
- 2.12.5.** During construction, the Contractor will develop templates to track sustainability compliance for VOC Content levels product material disclosures, and regional materials.
- 2.12.6.** Continuous Commissioning® (CC), or similar philosophy, will be reviewed and discussed with HAS for possible implementation. Training will be completed before commissioning, after occupancy, and one year after occupancy.
- 2.12.7.** Select mechanical equipment that uses only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.

Part 3 – Execution

3.1. Installation

- 3.1.1.** For all equipment and materials, installation will comply with manufacturers recommendations and the UMC, IBC and IEEE as amended by COH. All ductwork will comply with SMACNA.

3.2. Training

- 3.2.1.** All hydronic piping will be hydrostatically tested prior to placing in service. The Contractor will fill the system with water and hydrostatically test to a pressure 150 percent of the operating working pressure. During this process, all major equipment such as AHUs and pumps will be isolated. Once the test pressure is achieved, it must maintain the test pressure for a duration of four hours after the hydrostatic pump is removed. The test is successful with a zero pressure drop for the duration of the test.
- 3.2.2.** At successful completion of hydrostatic testing the system will be flushed for approximately two hours at a rate of 5 to 12 feet per second for a minimum of 15 minutes to remove any construction debris. During the flushing process, make-up water will be added at a rate equal to the flush water. A temporary trash pump will be used and all system pumps and major equipment, such as AHUs, must be isolated and bypassed.
- 3.2.3.** Once the system is flushed, the Contractor will refill, circulate, and add an approved chemical cleaner to the system at a concentration recommended by the chemical manufacturer. The system will be allowed to circulate at a minimum rate of 7 feet per second for a duration of 24 hours. At the completion of the 24 hours, the Contractor will flush the system with potable water. HAS will deem the test satisfactory when the flush water has reached the water quality standard for potable water. If the test fails, the Contractor will be required to repeat the chemical cleaning process until required results are achieved. The potable water parameters will be measured at the beginning of the test.
- 3.2.4.** All ductwork installed below the floor, in crawl spaces or below grade will be constructed with watertight joints and must be tested and proved tight before floors are poured. Under-floor duct systems will be constructed of fiberglass, PVC, or other approved non- metallic material.

27 - ARCHITECTURAL



27 – Architectural

Part 1 – General

1.1. Background

- 1.1.1. The Houston Airport System (HAS) Architectural Standards is a component of the overall HAS Design Standards (Standards) and includes terminal area development project types for new construction and renovation.
- 1.1.2. The Standards form a living document that will be updated as criteria change due to improved materials, methods, or decisions that arise from current and future design projects.

1.2. Purpose

- 1.2.1. The purpose of the Standards is to guide airport development projects in support of the HAS vision for airport development in:
 - 1.2.1.1. Providing safe and convenient facilities for passengers
 - 1.2.1.2. Maintaining the desired level of service to passengers and tenants during staged remodeling and new works
 - 1.2.1.3. Optimizing maintenance and operations efficiency
 - 1.2.1.4. Providing flexibility to accommodate public, airport, and maintenance functions that allows growth and change
 - 1.2.1.5. Providing modular systems that are built off-site and assembled on-site
 - 1.2.1.6. Incorporating sustainable design and materials
 - 1.2.1.7. Providing modular systems that will allow remodeling and updating as may be required for restrooms, counter systems, flooring, ceiling systems, retail, and food concessions
 - 1.2.1.8. Reducing maintenance and enabling ease of access for maintenance
 - 1.2.1.9. Providing flexible design to enable security, data and power updates to address changing conditions, provide redundancy, and additional space for equipment, conduit, raceway, and cable duct; all with easy accessibility.

1.3. Design Intent

- 1.3.1. Creative Freedom: The users of these Standards will include, but are not limited to architects/engineers (referred to as “Designer”), consultants, contractors, and HAS. It is not the intent of these Standards to limit or dismiss the experience or creativity of the Designer, but rather to identify ways in which projects can be developed to best meet HAS objectives.

1.3.2. Universal Design

- 1.3.2.1. In the context of the Standards, Universal Design is a design priority in which space planning, product selection, building component selection, and configuration ensure usability for all users with all types and levels of ability. This includes not only adults with special needs, but children and their caregivers.
- 1.3.2.2. Universal Design also helps to alleviate any stigma associated with signage and contrasting

products that are meant only for users with disabilities; allowing all user interfaces to be enjoyed by all users.

- 1.3.2.3. Houston serves as a destination for medical tourism, thus attention should be given to ease circulation for passengers with special needs. Special needs may include wheelchair accessibility, considerations for visual and hearing-impaired passengers, family restrooms, mother's lounges, and children's needs.

1.4. Quality Assurance

- 1.4.1. The Designer will define specific quality assurance requirements within the project technical specifications.
- 1.4.2. **Impact Insulation:** Provide floor to ceiling construction, including floor structure, floor finishes, and ceiling finishes, to insulate primary spaces from undesirable impact noise when adjacent spaces are occupied and are being used normally.
- 1.4.3. **Wear Resistance:** Provide interior construction and fixtures that are suitable and durable for the degree and type of traffic to be anticipated in each space.
- 1.4.4. **Ultraviolet Resistance:** In interior spaces exposed to direct sunlight, provide interior construction and fixtures that are inherently resistant to fading and discoloration.
- 1.4.5. **Vandal Resistance:** In spaces accessible to the public, and not subject to continuous surveillance, interior construction and fixtures will be inherently vandal resistant or designed to be difficult to access or damage.
- 1.4.6. **Cleaning:** Provide interior construction and fixtures that will not be damaged by ordinary cleaning and maintenance operation.

1.5. Shop Drawings and Submittals

- 1.5.1. Refer to requirements identified in Division 1 General Requirements and provide specific requirements within the project technical specifications.

1.6. Warranty

- 1.6.1. Designer will define specific warranty requirements within technical specifications.
- 1.6.2. **Warranty for Roofing Systems:**
 - 1.6.2.1. Roofing Contractor will provide a 5-year guarantee against leaks and defects in workmanship for the installed roofing system.
 - 1.6.2.2. Roof-related sheet metal, copings, edge strips and metal edges: Contractor will provide a 5-year guarantee against leaks and defects in materials and workmanship. Sheet metal exposed to public view will have a factory applied finish with a 20-year warranty covering fading, discoloration, peeling or other defects.
 - 1.6.2.3. Require roof manufacturer's total system, no dollar limit warranty for maximum time limit available. An example of this warranty is 5 years for liquid applied roofing systems and 20 to 30 years for all other acceptable roof systems, depending on roof system. Warranty will cover wind speeds, per the International Building Code (IBC) Standard, for peak gusts measured 10 meters above ground level.
 - 1.6.2.4. Warranty will cover related sheet metal copings, edge strips, and metal edges.

- 1.6.2.5. Warranty will cover repair of leaks caused by hail storm impact damage, or punctures by hail up to 3 to 4 inch in diameter, depending on roof system.
- 1.6.2.6. Warranty will also include 36 man-hours of labor per year throughout the term of the warranty for puncture repair work.

Part 2 – Products

2.1. Sustainability

- 2.1.1. HAS is in the process of developing an airport-wide Sustainable Management Plan. The Sustainable Management Plan includes Sustainable Design as a functional category and incorporates the goals of that plan into these design standards.
- 2.1.2. HAS will govern the design and construction of the facilities on Airport properties; with integrated sustainable design guidelines which support a comprehensive sustainability strategy. This includes the recycling of materials removed from construction sites and buildings, while designing energy efficient projects, the reduction of water use and power consumption, and a reduced waste stream.
- 2.1.3. The intent over time is to be able to demonstrate through measurable results, innovative design strategies for current and future airport projects.
- 2.1.4. Where applicable on a per project basis, the Designer will deliver Leadership in Energy and Environmental Design (LEED) as a standard of the design, without the application and reporting as required for certification and demonstrate compliance with the required prerequisites and credits noted in the Sustainable Design Guidelines Matrix. The Designer is requested to go beyond LEED minimums by meeting credits that emphasize sustainable project leadership, innovative design, and sustainable construction.
- 2.1.5. **Sustainable Design Practices**
 - 2.1.5.1. Track Designer-driven credits to ensure compliance using the Sustainable Design Guidelines Matrix and include in the Project Reports.
 - 2.1.5.2. Discuss, identify and document all applicable sustainable design opportunities.
- 2.1.6. **Sustainable Construction Practices**
 - 2.1.6.1. Develop and/or HAS-approved Contractor templates to track compliance with credits achieved on the final Sustainable Design Guidelines Matrix.
 - 2.1.6.2. Track Contractor-driven credits to ensure compliance.
 - 2.1.6.3. Discuss how sustainable construction will be implemented and how compliance will be monitored throughout construction.
- 2.1.7. **Water Management Plan**
 - 2.1.7.1. Identify, meter, and track water demands for all plumbing fixtures, irrigation, and cooling towers as applicable.
 - 2.1.7.2. Identify all potential water sources: greywater, reclaimed water, storm water runoff, municipal or well water.
 - 2.1.7.3. Identify and evaluate opportunities for water use reduction, capture, on-site treatment, and reuse.
- 2.1.8. Develop an energy management plan based on a simulation model compared to a reference building using ASHRAE Standard 90.1-2013, Appendix G, to evaluate the energy use of all of the building systems; to identify opportunities to reduce energy consumption, minimize use of available resources, and ensure the building uses at least 20 percent less energy than the

reference building.

- 2.1.8.1. Heating, ventilation, and air-conditioning (HVAC) and refrigeration
- 2.1.8.2. Lighting and daylighting controls
- 2.1.8.3. Domestic hot water systems
- 2.1.8.4. Building energy management system / controls
- 2.1.8.5. Integration of building management systems (BMS), reporting, and controls. High efficiency equipment
- 2.1.8.6. Baggage systems
- 2.1.8.7. Vertical and horizontal transportation
- 2.1.9.** Provide for material durability with design and selection of systems, equipment and products that are more durable, include longer lasting materials and finishes that will extend building life and reduce maintenance. Designer will address ease of access to simplify replacement of systems, equipment, and products.
- 2.1.10.** Consider selection and specification of local building materials and products located within the USA, the State of Texas, and preferably located in the City of Houston (COH) vicinity, when selecting materials and systems to support local businesses who hire locally.
- 2.1.11. Lighting:** Coordinate lighting levels with designed efficiency of glazing and lighting system controls. Demonstrate the economic operational efficiency of proposed solutions.
 - 2.1.11.1. For 90 percent of the regularly occupied floor area, meet the following thresholds for area-weighted average surface reflectance: 85 percent for ceilings, 60 percent for walls, and 25 percent for floors.
 - 2.1.11.2. If furniture is included in the scope of work, select furniture finishes to meet the following thresholds for area-weighted average surface reflectance: 45 percent for work surfaces, and 50 percent for moveable partitions.
 - 2.1.11.3. For 75 percent of the regularly occupied floor area, meet ratio of average wall surface illuminance (excluding fenestration) to average work plane (or surface, if defined) illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of 60 percent for walls.
 - 2.1.11.4. For 75 percent of the regularly occupied floor area, meet ratio of average ceiling illuminance (excluding fenestration) to work surface illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of 85 percent for ceilings.
- 2.1.12. Daylighting:** Perform a full annual sDA/ ASE simulation model to achieve at least a 55 percent sDA for regularly occupied floor area. Protect interior from glare and provide a comfortable, balanced lighting environment. The Designer will design lighting systems to address exterior sun angles, hours of the day by seasons, and varying weather conditions that affect interior lighting.
 - 2.1.12.1. **Electrical:** Consider the future implications of electric vehicle adoption and incorporate electric vehicle charging stations into parking lot and electrical supply designs.
 - 2.1.12.2. The designer should consult with mechanical and electrical designers to incorporate demand response into projects, as applicable.
- 2.1.13. Views:** Achieve a direct line of sight to the outdoors via vision glazing for 75 percent of all regularly occupied floor area.
- 2.1.14.** Develop and implement a construction and demolition waste management plan that establishes waste diversion goals and strategies for achieving these goals.
 - 2.1.14.1. Divert at least 50 percent of the total construction and demolition material; diverted materials must include at least three material streams.

2.2. Standards for Public Art

- 2.2.1.** Standards in public art planning, design, and construction are essential in the mission of identifying HAS facilities and the COH as a diverse international center for energy, innovation, and culture. HAS facilities will be understood as a platform for the creation of a unique airport terminal environment and a distinct Houston experience.
- 2.2.2.** Houston's two commercial airports, George Bush Intercontinental Airport (IAH) and William P. Hobby (HOU), have varying art works on display and integrated within the architecture or landscape. IAH is subject to the 1999 Civic Art Ordinance stating that 1.75 percent of construction monies in city-run projects must be allocated to art beautification. This does not, however, apply to runways, taxiways and ramps. As designated in the Civic Art Ordinance, HAS and all other city departments must partner, in project management, with the nonprofit organization Houston Arts Alliance.
- 2.2.3.** The artworks commissioned by HAS have been created by emerging, mid-career, and established artists from the regional, national, and international arenas. As part of the HAS mission, it is very important to foster the art community within Houston and exhibit works throughout the airport system.
- 2.2.4.** The HAS public art staff will work with the Designer to determine appropriate locations for permanent installations and establish design requirements for each identified location. Typically, locations chosen for permanent art installations are within centrally-located gathering spaces and high traffic areas. The nature of these types of locations is often large in scale, allowing permanent art installations to be easily and effectively incorporated. The art installation, however; will not adversely detract the passenger from its destination. Large, centrally located gathering points are often decision points. The art will complement and not deter from wayfinding, which is critical to facility functionality.
- 2.2.5.** The Designer will ensure that permanent art installations can be easily accessed for maintenance purposes and cleaned efficiently. The means and methods to conduct these types of tasks will be known and evaluated to determine their feasibility before a commissioned art piece is approved. Critical topics of discussion, such as specific maintenance procedures, frequency of maintenance, and disruption of operations during maintenance periods will need to be investigated. Equal consideration should be given to the materials incorporated within a permanent art installation. The inherent durability of a material and associated environmental factors may dictate maintenance requirements and procedures.

2.3. Signage and Wayfinding

- 2.3.1.** Signage coordination, in line with current knowledge of the psychology of wayfinding, is important to consider when incorporating a ceiling finish scheme that reinforces the passengers' intuitive wayfinding experience.
- 2.3.2.** All public, decision point interior wayfinding shall incorporate the Spanish language. Coordination with HAS Wayfinding Asset Manager shall insure correct translations.
- 2.3.3.** No vinyl floor graphic wayfinding will be accepted
- 2.3.4.** Current design standards describe a temporary sign type (foam inner core) and a permanent solution made of aluminum. HAS will determine the appropriate sign construction prior to design award.
- 2.3.5.** The decision to illuminate wayfinding will be made by HAS. All curbside wayfinding shall be illuminated.
- 2.3.6.** Refer and comply with Signage and Wayfinding Standards as published on the Fly2Houston website.

2.4. Curbside and Terminal Entrance

2.4.1. Pedestrian Safety

- 2.4.1.1. General street lighting must provide a safe drop-off and driving environment.
- 2.4.1.2. Lighted safety bollards will be located on the roadway sidewalk drop-off and aisle crosswalks to terminal sidewalks.
- 2.4.1.3. Provide traffic calming, textured road surfaces as required to reduce traffic speeds. Crosswalks must have a color change and offer low baggage wheel friction.
- 2.4.1.4. Bollards must be spaced no more than 36-inches clear between each bollard along the terminal frontage, adjacent to the curb line to restrict vehicle access. Consider design of bollards to be integrated with the terminal facility substructure for structural integrity, where applicable.
- 2.4.1.5. Design each drop-off point adjacent to terminal facility entrance doors for accessibility to the curbside. Provide removable bollards in front of passenger terminal facility entrance doors.
- 2.4.1.6. Consult with HAS on specific type and style of bollards for application to each project.
- 2.4.1.7. Wayfinding will identify air carriers, drop-off and pick-up points, directions to terminal parking, taxis, hotel busses, long-term parking busses, and other commercial vehicles.

2.4.2 Terminal Entrance Doors

- 2.4.2.1.1 Public entry to the terminal shall be through a conditioned vestibule accessible from the outside through automatic electrical sliding doors. A second set of automatic electrical doors shall separate the vestibule from the interior of the terminal.
- 2.4.2.1.2 Sliding doors shall have heavy duty extrusions with 3.5" wide door stiles with threaded rods and welded corners. The doors shall be actuated by motion sensors, shall be on emergency power and with full breakout capability for emergencies or to allow oversize entry to the terminal.

2.5 Check-In-Area

- 2.5.1. Provide areas for family seating, for people requiring assistance, and a repacking area within the check-in space and aligned with the check-in process to await the processing of baggage and assistance through agency screening to gates.
- 2.5.2. Counters for car rentals (as applicable to the specific airport and project), information and customer services support, re-ticketing, and concessions will be provided.

2.6. Terminal and Concourse Circulation

- 2.6.1. Public circulation spaces are unique in that they connect passengers to all public spaces within the terminal. They rely heavily on intuitive, architectural wayfinding strategies to assist the passenger in stress-free circulation movements to their destination. They also guide passengers into concessions areas, give passengers access to restrooms, and allow passengers to transfer between flights. As the main artery of the secure side of the terminal, it is fundamental that circulation spaces are planned with the upmost efficiency while providing the passenger effortless access and visibility to the services provided within.
- 2.6.2. Since the main circulation spaces serve to tie all public zones within the terminal together, it

follows that they will be spatially cohesive in form and finish. The overall character of these spaces must be focused on movement and will be contrasted against points of transition such as elevator and escalator cores (vertical circulation), holdroom thresholds, and concessions zones.

- 2.6.3.** With current understandings of the psychology of wayfinding, it is important to consider incorporating interior components and finishes that reinforce the passengers' intuitive wayfinding experience. It is also important to consider passenger walking distances. Moving walkways must be considered in all situations in which common passenger routes are more than 1,000 feet between points of interest.
- 2.6.4.** In zone interfaces where flows of passengers must move through a door between outdoor and indoor public circulation zones, doors will be fully automatic sliding doors to maintain circulation flow.
- 2.6.5.** Passenger circulation walkways must be minimum 25 feet wide and must be able to accommodate courtesy electric carts.
- 2.6.6.** Provide open and day lighted views to circulation areas where possible to enhance wayfinding.
- 2.6.7.** Heightened concentrations of waste and recycling receptacles will be provided within the public circulation zone at all food and beverage areas.
- 2.6.8.** Heightened concentrations of comfortable public seating will be provided within the public circulation zone at concessions areas to allow passengers to sit and rest, wait for other members of their party, and to mingle. This will help maintain a desirable space for passengers to prolong their time spent in concessions areas.
- 2.6.9.** Clear visibility into holdrooms from the circulation areas must be maintained. In addition to the gate signage in the public circulation area, visibility to the gate number and flight information at the holdroom check-in counter back wall must be maintained from the vantage point of the public circulation area.
- 2.6.10.** Passenger check-in counters will be set back a minimum of 16 feet from the edge of the concourse walkway to accommodate passenger queueing.
- 2.6.11.** Provide drinking fountains with bottled water refill dispensers located within primary circulation zones near each restroom entrance. Bottle filling stations should be located post security. Drinking fountains will be wall mounted in a recessed wall alcove. This is to create an inviting visual signal to passengers as well as to physically and psychologically pull passengers outside the main circulating paths of travel, thus aiding in passenger comfort and preventing circulation interference. Provide a prayer and abolition facility per concourse and locate these spaces within near proximity to restrooms.
- 2.6.12.** Vertical circulation points must be clearly visible from the vantage point of the public circulation area. These points must spatially stand out against the configuration of the primary circulation zone through which they are accessed.
- 2.6.13.** Provide stairs adjacent to escalators as a backup system when the escalator(s) may be out of service. Minimum escalator tread width will be a nominal 40 inches to accommodate a single passenger with carry-on baggage.

2.7. Gate Holdrooms

- 2.7.1.** Gate holdrooms will provide a waiting and seating area for passengers. In addition to the seating for passengers, holdrooms are to provide agents, airline operational equipment in the gate counters, and ticket podiums supporting flight management. Flight management will consist of seating re-assignments, ticket changes, and flight closeout printing.
- 2.7.2.** Gate counters and ticket podiums to be located left side, adjacent to doorways to loading bridges. Queuing without crossing paths with queuing in front of the podium. A back wall behind the podium will display relevant flight information on two minimum 42-inch liquid crystal display

(LCD) monitors.

- 2.7.3.** Adequate width will be provided for arriving passengers exiting the loading bridge to reach the sterile corridor. The exit must be clear of any obstruction to the public circulation walkway. During simultaneous operations, queuing for boarding will not obstruct the exit way to vertical access to the sterile corridor.
- 2.7.4.** Other objects located in the holdroom area, such as waste and recycling receptacles or planters, will not obstruct circulation.
- 2.7.5.** Signage for gate holdrooms will be clearly visible from the public circulation area. The flight information display on the back wall of the gate podium will be clearly visible to passengers walking toward the holdroom.
- 2.7.6.** Confirm applicability for carpet to be specified in gate holdrooms with HAS. If carpet is specified, products must be durable and easily maintainable. The carpet pattern will not be solid and the pattern will be of an appropriate scale to facilitate pattern alignment between installed sections. In new construction, provide structural floor elevations to permit flush finish transitions between holdroom finish floor and adjacent floor surfaces. If elevation differences between gate holdrooms and adjacent floor finishes is unavoidable, provide Universal Design compliant reducers between them. Extend carpet under the wall base.
- 2.7.7.** Wall finishes or column wraps in the holdroom areas will be of a durable finish and easy to maintain.
- 2.7.8.** Ceilings will be simple, uncluttered, well laid-out arrangements of modular, suspended ceiling systems which allow convenient access to recessed building infrastructure. Fixed ceilings, for example gypsum wall board (GWB), will be allowed only where no ceiling access and no acoustical properties are required. Spray-on acoustic absorbing materials will not be used. Ceilings must provide reasonable flexibility for coherent ceiling device layout. Devices may include, but not be limited to, air distribution devices, lighting, public address (PA) speakers, fire alarm devices, sensors, and closed-circuit televisions (CCTV). Colors of all materials attached to or installed within ceilings will be planned and coordinated into and within the overall ceiling system.
- 2.7.9.** The majority of ceilings in gate holdrooms will have sound energy absorbing qualities to promote clarity of public address systems.
- 2.7.10.** Ceilings over gate counters may be positioned lower than the dominant holdroom ceiling plane to draw visual attention to the gate counter area. Such ceilings may be modular, suspended, or fixed and may carry additional lighting. Consider using coves at ceiling/wall junctures to allow wall-washing cove lighting.

2.8. Concessions

- 2.8.1.** All concession spaces will be provided to tenants as a basic shell with metered power distribution panels and services terminated for chilled water, gas, public address, security, fire alarm, fire sprinkler, information technology (IT), and communication including interconnect point for building management system.
- 2.8.2.** The design of new exterior concession spaces will be sensitive to the principles and concepts provided in the HAS Tenant Design Standards. In addition, entrances and spaces will be inviting, well defined, and delineated using best architectural practices and principles. Lighting levels will be appropriate for the space and in general have a well-lit feel as opposed to dimly lit.
- 2.8.3.** The concessions are encouraged to be creative in the design to establish a distinctive and inviting image. The material used in the storefront will be of high-quality materials which are compatible with the public area of the concourses.
- 2.8.4.** The Designer will coordinate closely with HAS to develop a visually integrated storefront system including an expectation of a common soffit, roll up security grill. The concessionaire will provide

the storefront, soffit, and security grill at the concessionaire's expense.

2.4.2. Concessions Support

- 2.8.4.1. Provisioning hallway, segregated from public circulation, will allow consumable supply and waste removal, with goods and food products access to clean and waste elevators.
- 2.8.4.2. Separate receiving and shipping docks for goods. Dumpsters used for food waste will require refrigeration. Dry goods waste will require a consolidation area and compactor.
- 2.8.4.3. All incoming supplies and outgoing waste products will require security and customs screening. Shipping and receiving will have customs and security inspection points provided with offices, power, data communications, and toilet facilities are required.
- 2.8.4.4. Capability to support cleaning of waste compactor and truck dock. Provide water supply system, clean equipment in service area, with trench drain, and grease interceptor.

2.9. Airline Lounges

- 2.9.1. Design considerations of potential luggage and bag cart abuse will be considered in the layout and use of materials and finishes.
- 2.9.2. Airline lounges will require accessible service termination points for support utilities with connection points into adequately sized metered services. These include drainage inclusive of maintainable local grease interceptors, metered for power supply, connection points for water supply, gas supply with automatic shut-off on alarm, chilled water for cooling, fire systems and alarm, IT, and communications. Cooking with gas or electric will require a hood system with exhaust to the exterior, to be coordinated with the terminal facility infrastructure.
- 2.9.3. Provision for consumables waste removal, grease traps, dry packaging and supply of goods, and food products.
- 2.9.4. There will be separate receiving and shipping docks for goods with adjacent waste elevators provided, and clean receivable goods. Waste service areas for removal of these products and independent dumpsters will be used for food waste with timed pickups to keep food waste smell to a minimum. This design may require refrigeration. Dry goods waste may require a consolidation area and compactor system.
- 2.9.5. Capability to support full cleaning of these areas is required. Water system, drainage with provision to steam clean all service areas as necessary, with trench drain, and grease interceptor.
- 2.9.6. Customs service and security inspection with offices, supported by all utilities and services including toilet facilities, are required. All incoming supplies and outgoing waste products will require security and customs screening. If these areas cannot be co-supported due to distance from other waste collection and receiving points, they must be served from separate docks and clearance points.

2.10. Public and Non-Public Restrooms

- 2.10.1. Public and non-public restroom design including janitorial plumbing fixtures and accessories shall be in compliance with the current version of the HAS Modular Restroom Guidelines. Refer to the guidelines for architectural and interior finishes requirements in consideration for modular components.
- 2.10.2. Design each Men's and Women's Restroom so that half of the restroom may remain in service, while the other half is being cleaned or maintained.
- 2.10.3. Janitor closets and foot wash stations must be co-located with or near restrooms to enable ease of cleaning.

- 2.10.4.** Janitor closets must be large enough, with enough shelving, to store supplies and cleaning carts so that they are not in view of the public when not being used.
- 2.10.5.** A supply inventory room along with an equipment machine holding area with several electrical outlets must be located within the assigned terminal complex for efficient cleaning practices to take place on a daily basis.
- 2.10.6.** Refer and comply with Restrooms Standards as published on the Fly2Houston website.

2.11. Breakrooms

- 2.11.1.** Breakroom design including plumbing fixtures and accessories shall be in compliance with the current version of the HAS Breakroom Guidelines.

2.12. Pet Relief Areas

- 2.12.1.** Design considerations for pet relief areas will consider the guidelines included in the Service Animal Relief Areas in Airports - Guide from Open Doors Organization, most current version.
- 2.12.2.** Room locations for rooms dedicated for pet relief areas will be coordinated with HAS and relevant stakeholders.
- 2.12.3.** For mechanical and plumbing requirements refer to related HAS Design Standards sections.

2.13. Walls

- 2.13.1.** To keep a simple appearance and support more efficient maintenance, wall surface treatments will extend the entire length of a wall and not change materials side-to-side in the middle of a surface plane. Where walls extend to ceilings, all efforts will be made to match ceiling and wall patterns. Alternatively, it is acceptable to provide cove conditions to eliminate the need for pattern alignment.
- 2.13.2.** Edge conditions between materials will not be sharp, to minimize and eliminate injury or damage to people or clothing. Recess, fillet, rabbet or chamfer edge banding, and provide for flush material changes wherever possible.
- 2.13.3.** In high traffic areas such as terminals and concourses, durable materials will be specified from the top of base to a minimum of 48 inches above floor finish as protection against impact from hand- held luggage, luggage carts, electric cars, cleaning equipment, and other sharp or massive moving objects. Example materials include stainless-steel, hardwood panel, and fiberglass. Except for restrooms and concessions, all public areas will have resilient bases. Back of house areas such as rooms and janitor closets, will have rubber bases and highly durable, yet economical, surface treatment, up to a maximum of 48 inches above the floor finish.
- 2.13.4.** Provide corner guards at outside corners whenever possible. Corner-guards will be easily replaceable in case of damage. Due to high volumes of passenger traffic, many of whom travel with rolling baggage, corner guards must be provided on all vulnerable corners along all circulation corridors.
- 2.13.5.** All corner guards will be heavy duty brushed satin finished stainless steel flush mounted. Corner guards will be mounted to a minimum height of 48 inches above floor finish.
- 2.13.6.** Electrical and IT rooms must be separated from adjoining spaces with deck to deck partition walls.
- 2.13.7.** Restroom walls adjoining other spaces of the airport will be deck to deck solid partition walls.

- 2.13.8.** Wall surfaces must be easy to maintain with surfaces that can be repaired and cleaned with ease. Avoid use of materials that require periodic maintenance like painting or sealants. Walls and column finishes shall be resistant to scratches, smudges, fingerprints and scuff marks to a minimum height of 48 inches and should be easy to clean. Panelized wall finishes shall be demountable to allow replacement of individual panels if required.
- 2.13.9.** Wall surfaces must be designed to withstand extreme heat and humidity. In addition, wall surfaces must emit little or no formaldehyde or other VOCs.
- 2.13.10.** Finishes within public reach to a minimum height of 7 feet shall be impact resistant and easy to clean and maintain. Within public circulation zones, finishes shall be able to withstand the wear and tear of high passenger traffic, the frequent contact with baggage and cleaning equipment. Finishes must be easy to clean from dirt, liquid spills, smudges etc.

2.13.1 Ceilings

- 2.13.1.** Ceiling tiles that offer a high light reflective finish provide brighter spaces, reduced energy costs, fewer light fixtures, balanced diffusion, and reduced light loss. A light reflectance (LR) value of .88 is required.
- 2.13.2. Acoustical ceiling tile (ACT) Systems:** If lay-in systems are specified, the tiles will be smooth and therefore easy to clean. They must be off-white or neutral to delay the appearance of aging. The ability to match and replace system elements in the future will be considered.
- 2.13.3.** Wood ceiling systems is an appropriate choice for concourse public circulation zones. Linear systems can be used to reinforce wayfinding, and they can be more spatially appropriate for spaces of public movement. These systems provide acoustic benefits. They are modular, thus allowing access to the plenum space above. Individual panels do not need to be replaced as frequently as ACT tiles because they are of a more durable material. The system panels can also be refinished.
- 2.13.4.** Gypsum board ceilings can be considered in areas where access above is not required.
- 2.13.5.** Gypsum board will be used for wall and fully closed ceiling surfaces. In an airport environment, gypsum board will be used for ceiling surfaces and green board behind tiled surfaces.
- 2.13.6.** An advantage of acoustical ceiling tile is that the easily-removed ceiling panels offer ease of access to the plenum, which greatly simplifies repairs or alterations. By contrast, wiring and piping installed behind traditional plaster or wallboard ceilings is extremely difficult to modify once the finished ceiling is in place. Wires must either be fished through hollow spaces in the walls behind the finished ceiling, or the ceiling must be demolished for wiring or piping changes to be made. In contrast, the tiles and other parts of an ACT ceiling are easily removed to allow access to the area above the grid to do any necessary wiring or plumbing modifications. In the event of remodeling, nearly all components of the grid can be dismantled and reassembled somewhere else. Concealed grid systems are not to be specified.
- 2.13.7.** Ceilings will be designed to stand up to extremes of heat and humidity. In addition, ceilings will emit little to no formaldehyde, a common VOC found in many building materials. Ceiling tiles must include an antimicrobial treatment that provides broad- spectrum control for mold, mildew, and fungi over the warranty period.
- 2.13.8.** Provide insulation thickness to achieve thermal resistance of R-22 minimum, but in no case less than that required by the currently adopted edition of the International Energy Conservation Code (IECC).
- 2.13.9.** Impact resistance, scratch resistance, scrub ability, soil resistance, and wash ability are all specific areas of consideration in selecting the appropriate ceiling. Efforts will be made to ensure future availability of acoustic tile product to match initial installations.

2.14. Floors – General

- 2.14.1.** Floors in kitchens, food preparation and storage areas, counter, restrooms, and beverage service areas (wet areas) will be installed over a membrane waterproofing system. This system will result in a fully waterproofed surface, sealed at the drains, including a 6-inch high cove base backed with the membrane waterproofing or the flooring will be an epoxy non-slip coating system that can be applied over concrete substrate, existing tile, etc.
- 2.14.2.** Floor surface materials and finishes will be consistent throughout circulation walkways and within specific zones.
- 2.14.3.** Ceramic tiling and/or terrazzo can be used in public circulation walkways and concessions areas.
- 2.14.4.** Floor tiles will be easy to maintain and clean. A more slip resistant tile may be harder to clean since the texture and roughness of the tile also traps dirt and grime. The tile will be rough enough to provide a safe walking surface but not so rough that maintenance and cleaning becomes an issue. Subfloor concrete is to be treated with a post applied, self-adhered bituminous waterproofing, membrane over damproofing and waterproofing concrete.
- 2.14.5.** Flooring surface will be easy to clean and maintain. A smoother and less porous surface may produce an easier to clean surface, but the surface finish will not compromise texture required for slip resistance in wet conditions.
- 2.14.6.** The overall design of the resilient urethane mortar floor will be composed of complimentary, tone-on-tone colors in a pattern that could appear as random. The individual colors will be placed in large sections and separated from the other sections with aluminum or brass divider strips. The large sections must be designed and placed in such a way as to be easily replaceable in the event of cracking caused by substrate movement.
- 2.14.7.** Restroom environments are exposed to a lot of water and liquids resulting from drips, spills and cleaning, which utilizes a spray down method. A resinous flooring will be a waterproof, seamless system able to prevent damage from contact with moisture. To complete water resistance of flooring, a resinous cove wall base will be installed to protect the wall and floor edge from water intrusion.
- 2.14.8.** Install permanent entryway systems at least 10 feet long in the primary direction of travel to capture dirt and particulates entering the building at regularly used exterior entrances. Acceptance entryway systems include permanently installed grates, grilles, slotted systems that allow for cleaning underneath, rollout mats, and any other materials manufactured as entryway systems with equivalent or better performance.

2.15. Terminal and Concourse Flooring

- 2.15.1.** One of the most pervasive issues relating to the public circulation spaces is the variation of floor finishes and surface textures along a single path of travel. This not only poses a tripping hazard to passengers but is also inconvenient to passengers who travel with rolling baggage. Variation in coefficients of friction, as given by differing textures and finishes, cause passengers to readjust the force with which they pull their luggage. In moisture situations, such as rain or spills, sudden drops in coefficients of friction, for instance transitioning from carpet to polished terrazzo, cause passengers to more easily slip and fall.
- 2.15.2.** All transitions in floor finishes along a single path of travel and a primary public circulation corridor, will be characterized by minimal shifts in coefficients of friction to prevent passengers from losing their balance and potentially tripping and falling. Restrooms will have depressed slabs to allow positive drainage to floor drains. These drains will be located out of the main walking areas of the restrooms to limit water ponding that may contribute to slip and fall issues.

- 2.15.3.** Flooring along a single path of travel that spans a primary public circulation corridor will be without grooves or patterns that cause baggage carts and wheelchairs to vibrate or rattle.

2.16. Flooring Durability

- 2.16.1.** Since public circulation spaces are highly trafficked zones, the floor and wall systems within these spaces need to be composed of heavy duty components and have corner guards and crash rails. The corner guards or crash rails are floor or wall base mounted to prevent carts and equipment from contacting the surface. Guardrails along walls can also help to prevent passengers from contacting walls with their carry-on items as they move through circulation spaces. It may be appropriate to specify crash rails at the base of walls in highly trafficked areas.
- 2.16.2.** Ceramic tiles and grouting are porous materials allowing water to seep through. A waterproofing membrane is required to prevent surface water from penetrating to the subsurface.

2.17. Structural and Enclosure Elements

- 2.17.1.** The durability design of structural elements and their constituent materials will be based upon a useful life of at least 75 years. The materials used in structural elements, components, and assemblies will be resistant to or protected from damage by exposure to normal climatic or anticipated conditions. Special attention will be given to protect against corrosion or oxidation of metals, decay of wood and wood base materials, deterioration and spalling of concrete, leaching of mortar, and deterioration of adhesives. Dissimilar metals will not be allowed to come in contact with each other.
- 2.17.2.** Structural elements, components, and assemblies will be protected from condensed moisture or from collection of water, including building leaks, fire suppression, or other means, that could impair the structural adequacy through deterioration over time.
- 2.17.3.** Automatic sliding doors are encouraged, at two-way traffic areas, where the public is carrying baggage or boxes. Create vestibules for weather lock with dual pair of sliders. Vestibules are heated, when appropriate, and pressurized. Sliding doors, exterior of the façade system, will be fully water tight.
- 2.17.4.** Waterproof all floors, decks, and driveways above occupied space. All public restrooms require waterproofing at walls and floors. Waterproof all below grade structure with applied fibrous asphaltic forming a fully- bonded thermoplastic polyolefin (TPO) membrane system or equal, that offers high waterproofing safety and installation efficiency.

2.18. Roofing

- 2.18.1.** Existing roofs are primarily un-ballasted single-ply membrane roofing over metal deck and frame. If cast-in-place is the chosen assembly for a new roof deck, some moisture will remain in the concrete during the curing process even after the surface is dry. A vapor retarder is recommended between the concrete and subsequent roofing materials, such as insulation, to prevent moisture damage. Coordinate with roofing consultant and manufacturer for acceptable vapor retarder configurations and applications.
- 2.18.2.** Roofing will be designed per IBC Codes.
- 2.18.3.** Roofing for conventional roof systems to be a high performance fully adhered Ketone Ethylene Ester (KEE – ASTM D6754) system with minimum 60 mil membrane over cover board and rigid

insulation. Coordinate with membrane manufacturer for specific assembly for the project roof deck type, insulation required, and specified 20 year warranty requirements.

- 2.18.4.** Standing seam metal roof systems may be selected with prior approval from HAS.
- 2.18.5.** For roofs equal to or less than a 2:12 slope, roofing material must have an initial Solar Reflective Index (SRI) of at least 82. Roofs with slopes greater than 2:12 must have an initial SRI of 39.
- 2.18.6.** Glare reflective roof system finishes must comply with the Federal Aviation Administration (FAA) Standards to avoid reflections and glare. Reflections and glare could possibly interfere with the safe operations of aircraft and ground service vehicles or affect visibility from the air traffic control tower.
- 2.18.7.** For single-ply membrane roofing systems, roofing manufacturer's prefabricated multi-pipe penetration flashings, of the proper size and configuration for the specific condition, may be used. Metal penetration dams, pitch/sealant pans, will be permitted only with the approval of the HAS.
- 2.18.8.** Structural decks may be constructed of metal or concrete.
- 2.18.9.** Deflection of the structural deck must be considered and will be limited to 1/240th of the span.
- 2.18.10.** For steep slopes over 1½ inches per foot, properly designed and fastened or adhered Ketone Ethylene Ester (KEE – ASTM D6754) thermoplastic or metal roofs are acceptable.
- 2.18.11.** Roof materials and assemblies will be listed by Underwriters Laboratories, Inc. (UL) as a Class A roof assembly.
- 2.18.12.** Roof coping and metal edge materials, assemblies and securement will equal or exceed the current edition of the American National Standards Institute (ANSI)/ Single Ply Roofing Industry (SPRI)/FM 4485/ES-1 wind design standard for all low slope (<9.5° [2:12]) membrane roof systems.
- 2.18.13.** Internal gutters are not allowed.
- 2.18.14.** Gravel and rock ballast surfaces are not permitted.
- 2.18.15.** Walkway pads will be placed around all roof-mounted equipment requiring periodic service as well as pathways to roof access doors and equipment.
- 2.18.16.** Provide roof traffic protection at all parapets, around equipment and at all areas subject to frequent wear.
- 2.18.16.1.** Ponding is defined as standing water on roofs for more than 24 hours. Ponding water is not acceptable.
- 2.18.19.** Roofs are to be designed for a positive slope, with appropriate saddles and crickets to drain. Drains are to be located at the lowest points and at maximum points of deflection, not near expansion joints. If drains are required to be placed near columns or bearing walls, the slope of the roof needs to be increased to compensate for the minimum deflections existing at these locations, and still achieve drainage. Both the number and size of drains must adequately address 100-year storm event. Primary drains and scuppers are to be recessed, sump, below the roof membrane surface.
- 2.18.20.** All flashing is to be corrosion resistant in atmospheres within a fuel, acidic environment, and be fabricated and installed in accordance with Sheet Metal & Air-Conditioning Contractor's National Association (SMACNA), the Architectural Sheet Metal Manual. Consult with HAS on flashing materials specific to the project.
- 2.18.21.** Metal counter flashing, covering the top flashing edge by 4 inches minimum, must protect all curb-mounted equipment flashing.
- 2.18.22.** Minimum flashing heights will be 8 inches above roof surface to the extent possible by existing design conditions. However, in no case will flashing height be less than required by the roof system manufacturer for the applicable warranty.
- 2.18.23. Roof Penetrations:** All pipe and conduit penetrations will be securely anchored to the

structure below the roofing system. All single pipe and conduit penetrations will be flashed to the roofing system with roofing system manufacturer approved penetration materials and details. All multi-pipe and conduit penetrations will be through covered metal pipe enclosures like SMACNA. Locate roof penetrations to allow for proper flashing installation.

- 2.18.24.** Rigid roof insulation, such as polyisocyanurate, with rigid boards are to allow for attachments of roofing products. This is to be used for new construction to serve as insulation for the building, substrate to which the roofing membrane is applied, as well as for providing support for periodic foot traffic associated with roof maintenance. The required R-value, shall be as required by code but no less than R-25 for the entire roof assembly, needs to be considered when specifying a product. Refer to the IECC code for the COH as a minimum for the R-value for both occupied and non-occupied spaces. Roofing membrane manufacturers also need to be consulted for compatibility with their systems.
- 2.18.25.** Roof materials and assemblies will be listed by UL as a Class A roofing material or roof assembly.
- 2.18.26.** Slope: Provide a minimum ¼ inch per foot slope designed and built into the structure of the facility. Where the minimum ¼ inch per foot slope is not designed nor built into the structure of the facility, the ¼-inch slope will be achieved using a fully tapered insulation system and/or crickets, saddles, or a tapered insulation system.
- 2.18.27.** Provide crickets and saddles between drains with a resultant, ¼ inch per foot slope, to direct all water flow to the drain.
- 2.18.28.** Locate drains a minimum of 36 inches from equipment and perimeters to allow proper sump and flashing details.
- 2.18.29.** Provide 48-inch by 48-inch minimum sump around each drain, with resultant ½-inch per foot slope, to direct all water flow to the drain.
- 2.18.30. Deck Conditions:** Existing condition and type of deck (to the extent determinable by limited investigation), slope, and allowable superimposed load (if available from HAS archives) must be documented prior to roof system selection. Ponding longer than 24 hours, deck deflection, and other problems areas must be documented.
- 2.18.31. Overflow Drains:** Building maintenance projects, including roof replacement projects with like kind roofing, do not require upgrading the overflow drain system to meet current code. If the drain system complies with the building and plumbing codes in force when the building was constructed, and the overflow drainage system is not changed by the new roofing, then no code upgrade is required. However, new scuppers or internal overflow drainage will be added when deemed feasible by the Building Official. In addition, any new or reconfigured roof drains from terminal, hangar, and air cargo building roofs will not be allowed to drain onto the ramp.
- 2.18.32.** Minimum drainage to roof drains will not be less than ¼ inch per foot in accordance with the currently adopted edition of the IBC.
- 2.18.33.** Antennas mounted on the roof will be mounted on bases, non-penetrating where practical, designed for this purpose or to roofing system penetrating support post(s) securely anchored to the building's structure below and properly flashed to the roofing system.
- 2.18.34. Roof Safety:** The roof will have safety lines and tie off provided and/or edge protective parapet.

2.19. Casework Components

- 2.19.1.** There are two different kinds of airport casework: shell and insert and fully integrated. The Designer will first determine which application is required for all new and/or replacement projects.
- 2.19.2.** In shell and insert applications, the inserts are typically provided by the airline and the design

of the shell is made to fit around the insert and comply with these Standards. Standard airport casework shells consist of the following elements:

- Framework
- Removable front panels
- Side panels
- Base panel

- 2.19.3.** There will be space within the shell for electrical and data cables. Any casework that supports prolonged agent-to- passenger transactions will likely include transaction turrets and purse shelves.
- 2.19.4.** Fully integrated designs provide completely functional casework, with inside functional to the operator's specifications, and must meet HAS standards. Standard fully integrated casework elements include, in addition to the shell set, all inside structure, shelves, cabinets, drawers, cubbies, open areas for equipment, countertops, plus all cabinet hardware required for operation.
- 2.19.5.** The framework will consist of structurally sound, dimensionally stable elements glued and fastened together to accept and support fixed and removable components. Fasteners will be non-corrosive.
- 2.19.6.** Exterior panels and transaction turrets will be faced on exterior side with materials of durable quality, must exhibit a matte and even appearance, and must be highly resistant to dents, scratches, nicks, and other deformities caused by arbitrary public abuse. The base panel will be of extra-high durability. Color and finish must be fade resistant, with a uniform color throughout the finish and from panel-to-panel and will not exhibit visual changes in color and evenness when scratched or nicked.
- 2.19.7.** Casework installments must be dimensioned to accommodate airline and airport equipment, support operational functionality foremost, and will be of Universal Design wherever possible. Americans with Disabilities Act (ADA) compliant transaction areas will be included.
- 2.19.8.** Casework installation will be coordinated with building power, communications and data installations, and will be fed through the floor wherever possible.
- 2.19.9.** Gate counter back walls will be dimensioned the same in width and be positioned in alignment with gate counters.
- 2.19.10.** Casework will be factory produced, interchangeable for flexibility, designed with concealed fasteners, and will be rigid, sturdy and give an overall neat and unobtrusive appearance, showing no loose or poorly constructed joints. Base element is to be protected with stainless-steel base material.
- 2.19.11.** Select finish materials that are expected to be available into the future.
- 2.19.12.** Trim and edge protection will be of
- 2.19.13.** stainless-steel #4 brushed finish.
- 2.19.14.** Use master keying system for all locks.
- 2.19.15.** Provide easily accessible power and data raceways.
- 2.19.16. Check-In Counters**
- 2.19.15.1.** Provide two-person counter positions at gates and a pair of single independent counters, with a minimum separation of 16 inches for employee access behind counters.
- 2.19.15.2.** Consider independent agent baggage weighing scales provided with transfer conveyor with turning roller at takeaway conveyor.
- 2.19.15.3.** Provide a minimum of 6 feet from front face of takeaway conveyors, allowing 32 inches for counter depth and 36-inch width.
- 2.19.15.4.** Provide passenger access for bag drop and for check-in. Counter towards queuing line will be a minimum depth of 96 inches.

- 2.19.15.5. Queuing line minimum is 54 inches wide with turning points in switch back queuing of 60 inches. Provide minimum seven passengers, with 20 to 25 feet queuing depth, with baggage with a planned five-minute wait time. This wait time allows for two-and-a-half minutes each check in, excluding excess baggage and weight fees being collected, with passengers departing with no less than 1.8 bags per passenger. This is assuming peak hour adjustment for minimum level of service C taken within IAH for foreign carriers. Domestic carrier bag counts and checking in times to be adjusted by analysis of passenger numbers and bags being checked.
- 2.19.16.** When providing new customer service counters in holdrooms, they must be manufactured out of materials that are highly durable, easy to maintain, have low life cycle costs, and are readily available now and in the future. The use of sustainable materials and design is highly preferred.
- 2.19.16.1. New counters will be laid out with a single unified counter system as opposed to combining several smaller movable cabinets side by side. The length of the counter will be sufficient to allow two people to work side by side comfortably. The working floor space will be a minimum of 36 inches wide for each counter work area and allow for two people to pass each other. Storage cabinets and countertops may also be provided together with a back wall. Doors are not required to enclose the space.
- 2.19.16.2. Each customer service counter will provide an accessible countertop workspace per the Accessibility Guidelines for Buildings and Facilities (ADAAG) Standards. Provide ample room for computer monitors, computer accessories (keyboards, etc.), peripherals (printers, etc.), and working area. Provide wiring access holes and cover plate solutions for data and power cables. Provide data, power, and communications outlets at the countertop level as required.
- 2.19.16.3. Provide new storage cabinets below countertops. Provide doors and drawers with cam locks which are master keyed and keyed-alike. Storage areas will have ample room for computer systems, dedicated wiring spaces, and additional storage. Cabinet areas used for computer or electronic equipment must be provided with adequate ventilation as required. All wiring will be concealed within the cabinets and organized in a neat, professional manner. Exposed wiring is not allowed to be laid on the floor. Provide required number of data, power, and communication outlets on the floor under each cabinet. Provide access panels on the inside of cabinets to allow ample access to data and power outlets.
- 2.19.16.4. Provide ceiling mounted video display monitors above each customer service counter to provide flight information and aid with other customer service needs. Pedestrian control devices, such as post and retractable belt queue management systems, are recommended for each counter area.
- 2.19.16.5. Gate counters are used as the last checkpoint prior to boarding the airplanes. This is where the boarding passes are collected. At each gate, the podium needs to accommodate a minimum of one computer system, related accessories, peripherals for the system(s), and the two boarding pass collection machines. The area should allow for two airline personnel to operate comfortably and efficiently. Provide data, power, and communications outlets at each station as required. A minimum of one boarding pass collection machine will be provided at an ADAAG compliant height, if automatic collection machines are provided.
- 2.19.16.6. If podium casework is provided, it will be similar in design and construction to customer service counters in holdroom areas. Pedestrian control devices, such as post and retractable belt queue management systems, are recommended for areas leading to boarding gates.
- 2.19.16.7. If podiums and related furniture are provided by the airlines, they must consult with HAS prior to specifying.

2.20. Seating

- 2.20.1.** In general, seating will be comfortable, durable, and easy to maintain. Seating dimensions will be generous enough to accommodate people of various sizes as well as provide space underneath the seat to place carry-on luggage.
- 2.20.2.** Modular seating material will be comfortable and padded, wrinkle-free, damage resistant, colorfast, highly rust-resistant, water-resistant, easy to clean, and have a minimal amount of grooves and/or stitching. Provide intermediate table attachments as required for comfort and practicability based on project requirements.
- 2.20.3.** Provide power points above floor level, located at/or within seating units.
- 2.20.4.** Multiple seating units in public areas will fit in with the materiality and overall spatiality of the terminal. This seating will be inviting to passengers and provide an appropriate resting point along public circulation paths of travel.
- 2.20.5.** For security purposes, this seating will be open underneath to dissuade the hiding of explosive devices. Open areas beneath the seating will also provide a place for passengers to temporarily stow their luggage without interfering with public circulation.
- 2.20.6.** This seating will be of high quality commercial grade construction that is durable and easy to wipe down by maintenance staff. Seating must also accommodate power and data connectivity.
- 2.20.7.** Hold room seating must be durable, cleanable and open below; arranged so that passengers can have a good view of the boarding area. There will be adequate spacing between seating areas so that passengers with their bags can walk through while others are seated.

2.21. Acoustics and Noise Reduction

- 2.21.1.** Designer is responsible to perform acoustics calculations, reports, and recommendations to assure that public announcements and emergency notifications can be clearly understood throughout the facility.
- 2.21.2.** Insulated walls are required for sound reduction between halls, concourses and offices, conference rooms, restrooms, public meeting rooms, retail, food and beverage areas, governmental agency interview rooms and holding rooms, nursing and medical service areas, and others programmed areas specific to the project. Composite sound transmission class (STC) ratings should exceed 50 between adjacent spaces.
- 2.21.3.** Noise reduction within departures hall, lounges, hallways, and all functions throughout a terminal facility must be addressed in the construction documents, including final selection of systems, equipment, and products utilized.
- 2.21.4.** Provide for sound quality in all public spaces. Provide interiors with acoustics where speech/paging through loudspeaker system is clearly comprehensible.
- 2.21.5. Reverberation Time:** Ensure sound reverberation times of under 1.5 seconds for all large capacity spaces with speech amplification, under 0.6 seconds in office buildings and similar spaces.
- 2.21.6. Background Noise:** Provide interiors that maintain ambient sound levels in primary spaces within noise criteria (NC) ranges, as generally defined in the current edition of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) HVAC Applications Handbook, when adjacent spaces are occupied and are being used normally.

2.22. Conveyance Systems

2.22.1. Manufacturers: Independent manufacturers to be used as the basis of design are as follows:

- **Hydraulic / Traction / MRL Elevators:**
 - Canton Elevator, Inc. Canton, OH
 - Minnesota Elevator, Inc. (MEI) Mankato, MN
 - Delaware Elevator, Inc. Salisbury, MD

- **Traction Elevator Hoist Machine:**
 - Hollister Whitney Elevator, Quincy, IL
 - Nidec (Imperial Electric), North Canton, OH

- **Control System (All Elevator Types):**
 - Smartrise Engineering, Sacramento, CA

- **Escalator and Moving Walkways:**
 - Kone, Inc.
 - Schindler, Inc.

2.22.2. Products will provide a minimum 15-year service life with service reliability expected of heavy duty service with 24-hour operations as defined in ADAAG Section 4.10 and ASME A17.1.

2.22.2.1 Elevator company shall have a minimum of 15 years' experience in manufacturing, installing elevator, troubleshooting, managing projects, servicing elevators of any type.

2.22.2.2. Elevator company shall have service office and full time service personnel within a 50 mile radius of the project site.

2.22.2.3. The architect or engineer and HAS Owner shall be the sole judge of quality equivalence of equipment, materials, installations and methods.

2.22.2.4. The engineer and HAS Owner shall investigate all request for substitution when submitted in accordance with above and if accepted, will issue a written acceptance.

2.22.3. Passenger and Service Elevators: The Designer will provide the type and size of elevators to conform to meet or exceed passenger or cargo requirements for each elevator location. HAS recommends that conventional in-ground hydraulic elevators be specified where there is not occupied space below the elevator hoistway, and where applicable for the service application.

2.22.3.1. For hydraulic elevators, include the following design considerations:

- Dry, belt driven, power units will be used
- **No telescoping hydraulic cylinders will be used**
- Non-conventional (recycled or vegetable type) hydraulic oil will not be used
- Power units must not be installed in the elevator pits
- Elevator control systems will not be installed in the elevator hoistway door frames
- Elevator control systems will be non- proprietary from Smartrise Engineering, Inc
- Provide Sump pit and oil interceptor

- Provide Heating and ventilation hoistway and machine rooms
- Provide Heat on hoistway and smoke sensing devices on floor level
- Provide GFCI receptacle protected and emergency lighting in machine room, hoistway and pit.
- Provide phone line to elevator
- Provide electrical service, emergency power supply, transfer switch and auxiliary contacts to elevators

2.22.3.2. Where the speed of the car is greater than 200 feet per minute, specify traction elevators. For traction elevators, consider the following in the design:

- Traction elevators must use conventional traction steel wire ropes. No Arimid fiber or Noncircular Elastomeric Coated steel belts as defined by ASME A17.6 (2010) Standard for Elevator Suspension Systems will be allowed. Elevator control systems will not be installed in the elevator hoistway door frames.

2.22.4. Two basic types of traction elevators are required. Dual Use / Passengers elevators will be designed with a minimum contract load of 5,000 pounds. Special service elevators will be designed for a contract load of 6,000 pounds. Service elevators should be provided with bi-parting freight doors to prevent damage from hand trucks, and other carts.

2.22.4.1. Should the Designer propose glass elevators that are accepted by HAS, special care will be taken to design and coordinate details and construction. Exposed surfaces will be detailed and constructed with consideration of aesthetic, durability and maintainability. The manufacturer of the elevator will provide special procedures for the safe cleaning of the glass surfaces.

2.22.4.2. The number of elevators will be determined by the Designer, based on walking distances and dwell time at each stop, that provide a Level of Service (LOS) of B (or greater) with potential short-term degradation of LOS C during the peak hour.

2.22.4.3. Elevators shall be sized as a minimum, no less than the National Fire Protection Association (NFPA) Fireman's Lift and American Society of Mechanical Engineers (ASME) A17.1 requirement. Size elevators by operational load requirements and number of passengers per design calculations.

2.22.5. Escalators: The Designer will provide the type and size of escalators as required by passenger flow studies to identify peak demand. The number of escalators will be determined by the Designer based on functional requirements of the architectural design achieving a Level of Service (LOS) of B (or greater) with potential short-term degradation of LOS C during the peak hour. Provide redundancy at key nodes. Escalators will be designed for sleep mode operations.

2.22.5.1. Escalators will have a minimum width of 40 inches and a minimum headroom of 86 inches. Maximum slope of the escalators will be 30 degrees.

2.22.5.2. All escalators will be rated for heavy duty or Transit level use and designed for continual operation.

2.22.5.3. All escalator steps must be black with yellow demarcation lines to enhance safety.

2.22.5.4. Comb segments / teeth will be painted yellow at both the entrance and exit ends of the escalators for safety.

2.22.5.5. All escalators must be installed with lubricant-free step chains.

2.22.5.6. Safety signs required by ASME A17.1 will be provided in both English and Spanish.

2.22.25.7. Safety: Contractor shall follow the elevator and electrical safety LOTO, OSHA Rules and Regulations and any safety when working on elevator.

2.22.25.8. Company project manager shall evaluate and monitor the installation including operations.

2.22.6. Moving Walkways: The Designer will provide the type and size of moving walkways based

upon design to support passenger load calculations at peak hour capacity. Design will be as per ASME A17.1. Moving walkways will be installed in concourses, dependent upon passenger travel distance. Actual lengths of moving walkways will be determined in conjunction with code requirements and the location of services as toilets, concessions and passenger gate access mechanical rooms for HVAC and smoke evacuation. Moving walkways to be minimum 40 inches wide. Moving walkways will be designed for sleep mode operations.

- 2.22.6.1. All moving walkways will be rated for heavy duty or Transit level use and designed for continual operation.
- 2.22.6.2. All moving walkways will have black pallets.
- 2.22.6.3. Comb segments / teeth will be painted yellow at both the entrance and exit ends of the moving walkway for safety.
- 2.22.6.4. All moving walkways will have lubricant- free pallet chains.
- 2.22.6.5. Safety signs required by ASME A17.1 will be provided in both English and Spanish.
- 2.22.6.6. Safety: Contractor shall follow the elevator and electrical safety LOTO, OSHA Rules and Regulations and any safety when working on elevator.
- 2.22.6.7. Company project manager shall evaluate and monitor the installation including operations.

2.23. Smoking

- 2.23.1. Smoking will be prohibited inside and outside the building except in designated smoking areas located at least 25 feet from all entries, outdoor air intakes, and operable windows, this includes during construction processes. No smoking signage will be posted within 10 feet of all building entrances. Smoking is also prohibited outside the property line in spaces used for business purposes. If this requirement cannot be implemented because of code, provide documentation of these regulations.

Part 3 – Execution

3.1. Installation

- 3.1.1. Designer will define specific installation requirements within the project technical specification sections.
- 3.1.2. Provide dedicated 20-amp, 125-volt circuit GFCI receptacle protection with weatherproof cover (WP) in the elevator pit.
- 3.1.3. Provide dedicated 20-amp, 125-volt circuit for two (2) LED strip lights with weatherproof and/or dustproof lenses in the elevator pit.
- 3.1.4. Provide dedicated 20-amp, 125-volt circuit GFCI receptacle protection with weatherproof cover (WP) for the elevator submersible pump.
- 3.1.5. Provide and install a heat sensor on top of the elevator shaft and smoke detector each outside the elevator floor(s).
- 3.1.6. Provide an access pit ladder above the floor level enough clearance for personnel getting out the pit and free from touching the side of the car.
- 3.1.7. Provide a steel barricade around the top of the car cabin from sides and back.
- 3.1.8. Contractor shall provide and deliver to the HAS Owner for printed for proper use of any tool that maybe necessary to perform diagnostic evaluations, system adjustments and parametric software.

- 3.1.9.** Provide hoistway ventilation shall be in accordance with local and national building code requirements.
- 3.1.10.**
- 3.1.11.** Safety: Contractor shall follow the elevator and electrical safety LOTO, OSHA Rules and Regulations and any safety when working on elevator.
- 3.1.12.** Drawings: Drawings shall be in three-ring binder the schematic, wiring, construction drawings, cut-sheets, and other drawings with Table of Contents. Keep the drawings clean free from stain and dirt.
- 3.1.13.** All disconnecting means switch shall have a bakelite label indicating the voltage, amperage, phase, hertz and where is feed from.
- 3.1.14.** The elevator shall be inter-phase with the fire alarm system.
- 3.1.15.** All junction boxes, pull boxes, conduits and branch conductors shall be label and marked with circuit number.
- 3.1.16.** No foreign piping shall pass-through the elevator hoistway.
- 3.1.17.** All conductor wiring inside the controllers shall be neat lace and uniformity.
- 3.1.18.** Housekeeping: The elevator pit, top and inside the cabin, equipment and elevator rooms shall be clean and vacuum free from dust and debris especially the elevator room during the construction.
- 3.1.19.** Provide maintenance program for period of one year from the Date of Completion after all punch list, testing and training are complete.
- A. Maintenance work shall be bi-annual service of the equipment, lubrication, cleaning the (machine room, hoistway pit, top of the car and door tracks) adjustment, oiling, greasing, parts and other services necessary for proper performance.
 - B. Provide trained personnel to perform the service task during regular working hours.
 - C. Submit parts catalog and show evidence of manufacture parts inventory with complete list of recommendation spare parts.

3.2. Training, Inspection, and Testing.

- 3.2.1.** Designer will develop commissioning and testing specifications for project products and systems based on Division 1 General Commissioning Requirements specification and as defined by the Project Commissioning Plan.
- 3.2.2.** Designer will define specific training requirements within the project technical specification sections. Refer also to the HAS Operational Readiness and Airport Transfer (ORAT) Standards.
- 3.2.3.** Contractor shall provide 4-hour training and outline about the operation of the elevator, parts and materials, elevator safety, procedure of emergency call out repair and monthly required inspection (provide monthly inspection chart). The trainer shall have the required certified training about the elevator equipment, elevator installation, elevator safety, elevator maintenance work, elevator parts and qualification and competent to provide the elevator training.
- 3.2.4.** HAS representative inspector(s) shall witness any load test, testing, and training. Notify at least 24 hours in advance before the event.

28- POTABLE WATER



28 - Potable Water

Part 1 – General

1.1. Service Connections

- 1.1.1.** All public potable water systems for the Houston Airport System (HAS) facilities, upstream of the water meter, are owned, maintained, and operated by the City of Houston (COH) Drinking Water Operations Department. All proposed connections to, or extensions of, the COH's Public Water System (PWS) will be described by drawings, specifications, and contract requirements. This includes details of connections at the user side of the meter and actual connections to the City water main in accordance with the COH Houston Public Works Department (HPW) Infrastructure Design Manual (IDM), latest edition. All construction of public water mains and appurtenances will conform to the latest edition of the COH standard construction specifications for wastewater collection systems, water lines, storm drainage, street paving, and traffic. All products and piping will comply with National Sanitation Foundation (NSF) 61 or similar.
- 1.1.2. Private Connections:** All potable water systems downstream of the water meter, for facilities owned, operated, and/or maintained by HAS, are treated by the COH as private connections. All projects that need connection to the PWS require complete drawings and specifications for the connection(s). The COH provides water meters of various sizes at a cost to the project. The Designer must submit all required documentation to the COH for approval prior to any service connection to City PWS is permitted.
- 1.1.3.** Dual water services, connected to separate isolated sections of the PWS, will be provided where water usage requirements are such that 48-hour maintenance or emergency repair interruptions cannot be tolerated. Terminal facilities require dual water service connections for redundancy.
- 1.1.4. Tapping Fee:** All new or enlarged, permanent water meter installations served by HAS potable water distribution systems will be subject to an impact tapping/ connection fee. The impact tapping/ connection fee will be based on the size of the water meter and will be determined by using the current impact fee rates established by the COH Water Department. The impact tapping/connection fee must be paid during the construction phase of the project.
- 1.1.5.** Fire hydrant service lines will be designed per the COH IDM. See Section 4, Fire Protection and Alarm Systems.

1.2. Quality Assurance

- 1.2.1. Tapping Water Mains:** Where services require tapping to any existing water distribution main, the Designer will specify that the Contractor employ a qualified specialty contractor to perform this service. Tapping of all water mains will be done in accordance with the COH standards and requirements and must be coordinated with the HAS Project Manager.

1.3. Shop Drawings and Submittals

- 1.3.1.** Submit shop drawings for all products required to complete the work.

1.4. Warranty

- 1.4.1.** All products and/or workmanship will be warranted for at least one year after the date accepted by HAS and the COH.

Part 2 – Products

2.1. Piping and Fittings

- 2.1.1.** All water lines and appurtenances upstream of the water meter, will conform to COH IDM and Standard Construction Specifications.
- 2.1.2.** All facility service lines will be adequately sized to provide a minimum of 20 pounds per square inch gauge (psig). Normal main static pressures may be verified with the COH and/or by contracting an approved plumbing contractor to perform pressure tests in question.
- 2.1.3.** In meter vaults or mechanical rooms where a potable water or fire line penetrates walls or slabs, install Link-Seals to prevent moisture infiltration.
- 2.1.4.** Specify concrete with a minimum strength of 2,500 pounds per square inch (psi) in 28 days, to block each change in direction of the pipe line, and will substantially brace the pipe against undisturbed trench walls. All fittings will be wrapped in polyethylene, prior to thrust block placement, to allow future removal of concrete without damage to fittings. Concrete blocking will have been in place four days prior to testing the pipe line.
- 2.1.5.** Concrete thrust blocks will be installed for any change in direction, size, elevation, stops, and valves where thrusts may be expected.
- 2.1.6.** Potable water lines will conform to the following material requirements:
- 2.1.6.1.** Polyvinyl chloride (PVC) pressure pipe greater than 4 inches and up to 12 inches in diameter, will conform to American Water Works Association (AWWA) C900 Class 200, DR 14. Pipe will be furnished in ductile iron equivalents.
- 2.1.6.2.** PVC pressure pipe greater than or equal to 14 inches and up to 24 inches in diameter will conform to AWWA C905, Class 235, DR 18 and will be furnished in cast iron equivalents.
- 2.1.6.3.** Ductile iron pipe (DIP) will be Class 51 DIP, conforming to AWWA C150, AWWA C151, and having a cement mortar lining conforming to AWWA C104.
- 2.1.6.4.** Fittings for PVC and DIP pipe will conform to C-153 Class 350 compact ductile iron.
- 2.1.6.5.** Cast iron pipe and fittings utilized in PVC pipe installations, will be cathodically protected.
- 2.1.7. Underground Crossings:**
- 2.1.7.1.** Provide a minimum of 5 feet of clearance above the outside top of the utility casing to the top or the paving, or a minimum of 18 inches of clearance above the outside top of the utility casing to the bottom of the pavement base course. Whichever is more stringent.
- 2.1.7.2.** The carrier pipe will extend a minimum of 2 feet beyond the end of the casing to allow for flanged joints to be constructed.
- 2.1.7.3.** Install isolation valves on each side of aviation pavement crossings. Isolation valves will be installed on all other crossings except as specifically approved by HAS.
- 2.1.7.4.** Provide sufficient length to exceed the ultimate future development of the crossed structure.
- 2.1.7.5.** Waterlines will be restrained joint and will extend at least 15 feet past the last bend or the Runway

Safety Area/Taxiway Safety Area, whichever one is greater.

2.1.7.6. Use trenchless construction except as specifically approved by HAS.

2.1.8. All pressurized pipe will be installed within casings under roadways, taxiways, and runways. Casing pipe will be reinforced concrete cylinder pipe (RCCP) or PVC (Schedule 80 or AWWA C900). Steel casing pipe can be specified except that steel must be cathodically protected. Corrugated steel pipe will not be used as casing pipe. All applicable Federal Aviation Administration (FAA), State, and City guidelines will be followed.

2.1.9. All pipe installed within a sleeve will require Raci-Spacers, or approved equivalent, on 4-foot centers.

2.2. Private Side Valves

2.2.1. **Gate Valves:** Gate valves will be non-rising stem, solid-wedge gates with cast iron body and bronze mountings. Unless otherwise specified, valves 3 to 12 inches in size, with working pressures of 200 psi or less, will be in strict accordance with AWWA Standard Specification for Gate Valves for Ordinary Water Works Service, designation C509, latest revision. Gate valves with resilient seated gates, in accordance with AWWA C509, latest edition, are preferred.

2.2.2. **Bronze Gate Valves:** Gate valves 2 inches and smaller will be all bronze, non-rising stem, with wedge disc and screwed ends. Unless otherwise indicated, they will be for 300 psi working pressure, Crane No. 437 or equal.

2.2.3. **Outlet Valves:** Blind flanges or plugs, as applicable, will be furnished and installed on all valves located at outlet points or terminal points where the water main does not continue. Dead-end main structures will be avoided whenever possible. If unavoidable, dead-end mains will be designed to accommodate periodic flushing. A potential design alternative may be considered to install a flush point at the main's end.

2.2.4. **Air Release Valves:** Manual air release valves will be located on each side of main line valves and at other applicable locations. The valves will be comprised of a main line corporation stop, brass service fittings as required, a curb stop, and soft copper pipe with flared fittings. A nylon isolation bushing will be installed between the main and corporation stop. Automatic air release and vacuum release valves will be installed at high points on mains.

2.2.5. **Surface Boxes:** Surface box for manual air release, where required, will be cast iron box and lid. The surface box will be 12 inches deep and 12 inches in diameter. Raised letters on the cover will read "WATER."

2.2.6. **Valve Stacks and Vaults:** Valves or corporation stops buried in the ground, will be provided with cast iron valve stacks. The valve stacks will be of proper dimensions to fit over the valve bonnets and to extend to the finished ground line in paved areas or slightly above finished grade in other areas. Tops will be complete with covers and must be adjustable. Valve stacks will be set vertical and concentric with the valve stem. A concrete pad will be poured around all valve stacks when not in paved areas. Valves 16 inches and larger will be installed in a vault and gate. Valves 20 inches and larger will be installed with a bypass valve.

2.2.7. **Valve Flanges:** Flanges for valves will be drilled to match connecting flanges. All flanges will conform to the standard specification of the American National Standards Institute (ANSI). Flanges will be Class 300 for all pipe, fittings. Flange bolts will be coated for corrosion control.

2.2.8. **Blocking Under Valves:** All buried gate valves 12 inches or larger will rest on a concrete pad. The pad will extend for the full width of the trench to the back of the bell or flange. Concrete will be 2,000 psi for blocking valves.

2.3. Hydrants

2.3.1. For fire hydrants see Section 4, Fire Protection and Alarm Systems.

2.4. Meters

- 2.4.1. Water Meter:** Water meters will be sized in accordance with HPW and IDM for the service intended. Meters specified will be compatible with electronic data collection equipment to enable on-site electronic meter readings. Water usage will be recorded on both a visual odometer and in electronic memory.
- 2.4.2.** Meters up to 2 inches in size will be multi- jet type with magnetic drive and sealed registers. These water meters will meet or exceed the requirements of AWWA C708 for Cold Water Meters - Multi-jet Type.
- 2.4.3.** Meters greater than 2 inches will be turbine type. These water meters will meet or exceed the requirements of AWWA Class II Turbines standard.
- 2.4.4.** Alternatively, magnetic meters may be used as allowed by the COH.
- 2.4.5.** Registers for all meters will read in straight U.S. Gallons.
- 2.4.6.** Meters with Remote Transmitter Receiver (RTR) and pit electronics will have data profiling capabilities.
- 2.4.7.** Meters will be constructed of compatible metals throughout to prevent any corrosive reaction between component metals.
- 2.4.7.1.** 5/8-inch by 3/4-inch meter with RTR and pit electronics with 3-foot lead. Specify wire length if more than 3 feet is needed.
- 2.4.7.2.** 1-inch meter with RTR and pit electronics with 3-foot lead. Specify wire length if more than 3 feet is needed.
- 2.4.7.3.** 1½-inch meter with test plug, RTR, and pit electronics with 3-foot lead. Specify wire length if more than 3 feet is needed.
- 2.4.7.4.** 2-inch meter with test plug, RTR, and pit electronics with 3-foot lead. Specify wire length if more than 3 feet is needed.
- 2.4.7.5.** 5/8-inch by 3/4-inch meter with RTR and outdoor remote, not prewired. Specify lead wire length if more than 25 feet is needed.
- 2.4.7.6.** 1-inch meter with RTR and outdoor remote, not prewired. Specify lead wire length if more than 25 feet is needed.
- 2.4.7.7.** 1½-inch meter with test plug RTR and outdoor remote, not prewired. Specify lead wire length if more than 25 feet is needed.
- 2.4.7.8.** 2-inch meter with test plug RTR and outdoor remote, not prewired. Specify lead wire length if more than 25 feet is needed.
- 2.4.7.9.** Design of plumbing systems will allow sub-meters and data collection within the building.

2.5. Function

- 2.5.1.** All bends will be restrained, both horizontally and vertically, by the placement of concrete thrust blocks and mega-lug restraint joint.
- 2.5.2. Wet Connection:** At all points where, wet connections are made to existing lines, the tapping connection fittings will be supported by blocking up to the spring line with 2,000- psi concrete.
- 2.5.3.** Backflow preventers and/or reduced pressure zone backflow preventers will be used downstream of all

meters and anywhere the service line provides potable water for a domestic service. They also connect with other closed or chemically treated systems that could contaminate the potable water line. Drains off the backflow preventer assembly will be connected to the sanitary sewer. Taps to mains, to provide water for fire protection or other closed pipe systems, will have a double check valve assembly at the fire line tap. An alternate method of backflow prevention, consisting of a 12-inch air gap between an unrestricted overflow of an atmospheric makeup tank and the source of water, is also acceptable (break tank). All double check and reduced pressure backflow preventers must be certified for operation after installation by a Texas Commission on Environmental Quality (TCEQ) certified tester. All original test forms will be returned to the HAS project representative.

- 2.5.4.** Gate valves 16 inches and larger, will be installed with a bypass valve in a vault.
- 2.5.5. Blocking and Drainage:** Concrete blocking will be poured behind hydrants against undisturbed earth. Washed gravel will be placed appropriately around the shoe of the hydrant to effectively drain the hydrant barrel.
- 2.5.6. Meter Boxes:** Meter boxes or vaults will be specified for each meter. Meter locations will be identified on the drawings, will be outside the facility served, and at a location that is always accessible to utility personnel and service equipment. Construction details will be shown on the drawings including the details of all internal piping. Piping details will include a minimum requirement of two isolating valves, the meter, backflow device downstream of the meter, and any necessary additional fittings required to remove or service the water meter without closing valves at any location. All installations requiring 3-inch or larger meters will be provided with a bypass line and a gate valve and arranged such that the bypass can provide unmetered service to the facility during periods of time when the meter is being serviced or replaced. All meter boxes or vaults containing 3-inch or larger meters will be free draining or be provided with a sump pump which discharges into the nearest storm drain. All drainage design for meter vaults will be coordinated and approved by HAS. Meter boxes and vaults will have cast iron or steel deck plate covers as required to provide adequate service access to the meter location. Where the weight of the cover or cover sections exceeds 25 pounds, all meters will be provided with sensor extension cable for mounting the sensor on the top of the box or vault. This will make the sensor easily readable through a small access door in the cover.

2.6. Serviceability

- 2.6.1.** All facilities will have an emergency water supply connection for supplying potable water to the facility whenever the domestic water service line is drained for repairs.
- 2.6.2.** A new valve will be installed at the point of connection, for water main extensions to facilitate testing and chlorination of the new main prior to its placement into service.
- 2.6.3.** All gate valves will be non-rising stem unless otherwise indicated and will turn counterclockwise to open. Valves will be provided with a hand-wheel operator unless otherwise designated. Valves, or corporation stops for buried service, will be provided with 2-inch square nut operator and must be installed with extension stems where required to extend operating nut to within 12 inches of the finished grade.
- 2.6.4. Isolation for Maintenance:** All private fire hydrants will be isolated from the main waterline and from other water services. This will be achieved by the installation of a gate valve between the main waterline and the fire hydrant, in order to facilitate repair of the fire hydrant without having to shut off the main waterline.

2.7. Durability

- 2.7.1.** After the trench has been cut to a depth below the barrel of the pipe of 6 inches, the bedding will be brought to a point, slightly above grade with compacted material. The bedding material will then be

brought up in uniform layers of either side of the pipe and over the pipe to a point 12 inches above the top of pipe.

2.7.2. Bedding material will be #10 chat or cushion sand.

Part 3 – Execution

3.1. Installation

3.1.1. Follow industry common best practices for all installation.

3.2. Testing

3.2.1. Tests must be conducted to verify residual pressures and water flow in coordination with HAS.

3.2.2. Temporary Water Service (Backflow Preventer): All temporary construction water services will be provided with a line-sized backflow preventer, double check valve assembly, and water meter. Services will not be initiated until backflow prevention devices have been tested and approved for operation by a TCEQ certified tester. All original test forms will be returned to the HAS project representative.

3.2.3. Reduced Pressure Backflow Preventer: All pressure reducing backflow preventers that are installed to protect high-hazard services from back-flowing, must be tested annually from the date they are installed and certified by a TCEQ certified tester. This requirement will be stated in the project specifications as part of the operation and maintenance of the unit.

3.2.4. Before any newly constructed water main will be permitted to be placed into service in the potable water supply, it will be flushed or purged, sterilized, and tested to assure compliance with COH and TCEQ standards.

3.2.5. A COH representative will be present when taking a water sample after the waterline has been pressure tested and flushed.

3.2.6. Provisions will be made to flush the pipe with potable water until all dirt, sludge, and debris is removed. If flushing is unsuccessful, the pipe must be purged. No flushing water can be discharged directly into a storm drain. Flush water must pass through an established, best management practice device.

3.2.7. Perform hydrostatic pressure and leakage tests per methods and performance requirements of AWWA C-600. The pressure required for hydrostatic pressure tests will be a minimum 150 psi with 0 percent leakage for two hours.

3.2.8. Sterilization of the main will be accomplished by injecting calcium hypochlorite into one end of the line until water released from the other end indicates a chlorine residual of 50 parts per million. All valves will then be closed, and the solution will be allowed to disinfect the pipe for at least 24 hours. Provisions will be made for disposing all chlorinated water into the sanitary sewer system directly after completion of the sterilization process. No discharging of sterilization water directly to the storm sewer system is allowed.

3.2.9. Disinfection and sterilization will be performed in accordance with COH requirements and/or AWWA C601, latest edition.

29 - JET FUELING SYSTEMS



29 - Jet Fueling Systems

Part 1 – General

1.1. Overview

- 1.1.1. Design will comply with requirements of the American Petroleum Institute (API), and American Society of Mechanical Engineers (ASME) 31.3 and National Fire Protection Association (NFPA). The intent of the Houston Airport System (HAS) Jet Fuel design standard is to establish a baseline set of criteria for jet fuel systems anywhere in the HAS system.
- 1.1.2. All fuel system operations will be in accordance with the standards/procedures specified in appropriate American National Standard Institute (ANSI) and NFPA publications. Design of the fuel system will meet or exceed the applicable City of Houston (COH) Fire Code and applicable state and federal regulations.

1.2. Runoff Controls

- 1.2.1. The following measures will be incorporated to prevent contaminated runoff into the site drainage system:
 - 1.2.1.1. All areas of the bulk storage, fuel farm, jet fuel loading and unloading stations that are subject to oil spills will pass through API oil/ water separators before allowing discharge into the storm-water drainage system.
 - 1.2.1.2. Oil separators will be provided in the apron drainage system where aircraft is being refueled. The system will be designed per NFPA 407 and the Code of Federal Regulation (CFR), 40 CFR Part 122.
- 1.2.2. Contaminated runoff with pollutant concentrations greater than the Environmental Protection Agency (EPA) benchmarks will be directed through appropriate pollution abatement equipment or retained for enhanced treatment. The system must ensure that a reasonably foreseeable spill of an environmental contaminant, during both wet and dry weather, is passively contained such that no contaminant is discharged to waters of the state.

1.3. Fire Protection

- 1.3.1. In addition to providing fire hydrants in the fuel bulk storage and the fuel farm per NFPA requirements, fire protection using aqueous film forming foam (AFFF) will be provided for tanks, pumping stations, and unloading stations.
- 1.3.2. Annunciation of all active fire protection systems will be via the relevant Fire Alarm Data Gathering Panel (DGP) and will function as an integral component of the HAS Central Fire/Security System and the Intelligent System. Details of all installed annunciation and control panels will be submitted to the HAS Project Manager for review and approval prior to installation.
- 1.3.3. Deluge fire protection system will be designed in accordance with NFPA 15, NFPA 415, and as required by COH.

1.4. Quality Assurance

- 1.4.1.** Unless otherwise accepted by HAS, use manufacturers and installers that employ a Quality Management System, complying with the program described in ISO 9001 or a similar system. Design considerations will also include the involvement of HAS Infrastructure, operations and maintenance, and electric shops. Stakeholder involvement during design charrettes is key to the Quality Assurance program.

1.5. Shop Drawings and Submittals

- 1.5.1.** Submit shop drawings for all products required to complete the work.

1.6. Warranty

- 1.7.1.** All products and/or workmanship will be warranted for at least one year after the date accepted by HAS.

Part 2 – Products

2.1. Piping

- 2.1.1.** All piping material will be suited as outlined for application by the relevant codes and standards that prevail and as outlined below. All pipe will be carbon steel ASME B 31.3, ANSI RF150 # RF, Schedule 40, A106 Grade B or API 5L Gr B (PSL2); internally epoxy coated. The minimum design pressures will be 275 pounds per square inch gauge (psig).
- 2.1.2.** All below grade fuel piping and locations where the possibility of soil contamination by jet fuel exists, design, fabrication and installation will follow National Association of Corrosion Engineers (NACE) RP0169. All coatings submitted for approval must have documentation on coating characteristics and application thicknesses.
- 2.1.3.** All equipment and piping will incorporate appropriate corrosion control methods and will be inspected and approved by a NACE CP4 qualified technician. Refer also to Cathodic Protection Standards.
- 2.1.4.** Standards for jet fuel pipe materials are inclusive but not limited to:
- Pipe – CS 4 inches – 10 inches ASME B36.10, A106 Gr B or API 5L, internal Epoxy coated, 4-10 inches seamless, 12- 36 inches welded.
 - LR Elbows 45 & 90 deg – CS 4 inches up, rated as per pipe, ANSI B 16.9 (BW), ASTM A 234 WPB, internal Epoxy coated
 - Tee's, Con./ ECC Reducers, Caps, 4 inches up – rated as per pipe, ANSI B 16.9 (BW), ASTM A 234 WPB, ASTM A 105, internal Epoxy coated
 - Flanges 2 – 36 inches – ANSI B 16.25 (BW), 150/300 # WNRF (WN match pipe), ASTM A

105, internal Epoxy coated

- Blind Flanges 4 – 36 inches – ASME 16.5, 150# RF, ASTM A 105, internal Epoxy coated
- Orifice Flanges 4 – 36 inches – ANSI B 16.25 (BW), 300 # RF, ASME B 16.5, ASTM A 105, internal Epoxy coated
- Blind Flanges 4 – 36 inches – ANSI B 16.20, 150# RF, ASME B 16.20, 1/8 inch Thick Spiral Wound with 316SS Centering Ring, Flexible style
- Stud Bolt/Nuts, ASME B 18.2.1 / ASTM A 193 Gr B7 (Bolts) & ASME B 18.2.2 / ASTM A 194 Gr 2H (Nuts)

2.1.4.1. All Flanges will have smooth finish facings of 3.2 – 6.3 micrometer (um) roughness.

2.1.4.2. Stud bolts will be threaded entire length with two hexagonal semi-finished type nuts. Rust proofing for bolts and nuts will be cadmium plated. Cadmium will not come in contact with Jet A fuel; therefore, bolts and nuts will only be used of the Jet A equipment and piping.

2.1.5. Blast Cleaning: The internal and external surfaces of all linear pipe and fittings will be grit blast cleaned to Swedish Standard Sa 2.5 or the US equivalent prescribed by NACE in a climate-controlled environment. The whole coating will be inspected for holidays by an approved electrical detection system furnished by the contractor and witnessed by HAS.

2.1.6. Follow NACE RP0169 for underground-road cross casings as applicable. Casing pipe will be reinforced concrete cylinder pipe (RCCP) or polyvinyl chloride (PVC) (Schedule 80 or American Water Works Association [AWWA] C900). Steel casings can be used with proper cathodic protection. Corrugated steel pipe will not be used as casing pipe.

2.2. Storage Tanks

2.2.1. The tanks will be above-ground fabricated steel design per API 650. Fuel spill containments will be provided per NFPA 30 and 40 CFR Part 122. Use floating suctions to withdraw jet fuel from the tanks. Tank interior surfaces subject to corrosion will be lined with epoxy.

2.3. Filtering and Metering

2.3.1. Filtering of jet fuel through API type filter/ separators will be mandated for the following processes. Metering will be provided for inventory controls.

2.3.1.1. Tanker truck delivery before entering storage tanks.

2.3.1.2. Bulk fuel delivery by pipeline (future) before entering storage tanks.

2.3.1.3. Hydrant pump discharges before entering the distribution network.

2.3.1.4. Recirculated fuel including discharges from meter proofing stations before re-entering storage tanks.

2.3.1.5. Into-plane dispensed fuel from hydrant carts.

2.3.1.6. Allow at least one bar for head loss across each filter/separator.

2.4. Jet Fuel Pumping

2.4.1. Centrifugal pumps will be used for transfer, hydrant pumping and tank truck unloading.

- 2.4.2.** Do not use jockey pumps to maintain hydrant header pressure. Provide a flow-bypass with pressure regulating controls across the pumping manifold to avoid prolonged shutoff conditions in the pump discharge header during no or low demand periods before pump shutdown. The system pump will maintain a system pressure between 120 and 150 pounds per square inch (psi).
- 2.4.3.** Provide certifiable flow meters and pressure transmitters on the discharge header manifold to measure the product flow rates.
- 2.4.4.** Pump on/off controls and sequencing will be by programmable logic controller (PLC) from pressure and flow readings at the discharge header.

2.5. Hydrant Distribution Network

- 2.5.1.** A routing loop will be provided to supply jet fuel from the fuel farm to all aircraft parking positions via an underground distribution network. The loop will be consistent with current HAS design standards and consist of multiple lines of equal sizes.
- 2.5.2.** Pipeline velocity will be limited to 9 feet per second (ft/sec) for optimizing pumping head and minimizing water hammer efforts of long pipelines.
- 2.5.3.** Exterior coating on the steel pipe will be suitable to guard against soil corrosion. Use of cathodic protection will be thoroughly investigated due to effect of high ground water table onsite.

2.6. Fuel Hydrant Pits

- 2.6.1.** Apron hydrant pits will be provided for each aircraft parking position, one on each side of the aircraft, branching off from each of the two headers. Four pits will be provided for each of the A380 gates. Additionally, pits will be provided for fueling as determined by coordination with HAS.
- 2.6.2.** The pits will be of closed bottom design to prevent fuel leakage contamination into the ground.
- 2.6.3.** Hydrant pit valves will be pilot operated, deadman controlled type.
- 2.6.4.** Line pressure of 100 psi or as per current operational design will be maintained at the inlet of each hydrant pit valve. The inlet pressure at the aircraft fuel connection will not exceed 50 psi and/or as recommended by plane manufacturer.

2.7. Pipeline Sectional Isolation

- 2.7.1.** To safeguard against an accident or a fuel spill at one gate position that may cause a prolonged complete system shutdown, pipeline sectional isolation will be provided. At a minimum, provide sectional isolation as follows:
 - 2.7.1.1.** One isolation valve for each of five to six contact gate or hardstand positions.
 - 2.7.1.2.** At branch connections to Terminal(s) or Piers and future development or future loop extensions.
- 2.7.2.** Isolation valve will be housed in a covered valve vault with aircraft rated lid. Isolation valves will be the double block and bleed plug type designed for pipeline tight shutoff service, motorized as required by design. Motorized valves will operate on emergency backup power circuits where possible.

2.8. Emergency Fuel Shutoff (EFSO)

2.8.1. Provide an EFSO panic button at each of the following locations per NFPA 70 and 407, as a minimum:

2.8.1.1. Each contact gate, each hardstand position and fueling stand

2.8.1.2. Refuel truck loading station

2.8.1.3. Hydrant pumping station

2.8.1.4. Meter proving station

2.8.1.5. Others as required by codes or design

2.8.2. Activation of any EFSO button closes the nearest motor operated isolation valves to fully isolate an individual terminal or segment of hydrant fueling main as a primary response. Secondary response, if isolation valves do not fully close, it will shut off the hydrant pumps. Activation of EFSO at fuel storage facility shuts down pumps and closes tank outlet valves.

2.9. Function

2.9.1. Jet fuel will be supplied from the fuel farm through an underground distribution piping network and dispensed to the aircraft via fuel hydrants. Coordination will be done with existing facilities at all stages of design and construction. Refueling trucks will only be used to back up the fuel hydrant systems when coordinated with HAS.

2.10. Flexibility

2.10.1. The network will allow increasing of flow capacity to meet HAS Master Plan demands without installing new headers on existing apron pavements that would severely impact airport operations.

2.11. Serviceability

2.11.1. Complete system will be designed and installed to allow for quick isolation and maintainability. The main rings of the jet fuel distribution network from the fuel farm and the fuel transfer pipelines between the unloading and transfer facility and the fuel farm will be provided with a leak detection system of the pressure monitoring type. The system will be capable of being partially controlled and fully monitored automatically from the control room at the Fuel Farm.

Part 3 – Execution

3.1. Installation

- 3.1.1.** Follow manufacturer’s recommendations and industry common best practices for installation. All equipment and piping will incorporate appropriate corrosion control methods. All below-ground carbon steel piping to be used in the service of aviation fuel will be factory coated and externally wrapped and protected with protectant approved by the Designer.

3.2. Testing

- 3.2.1.** Subject the fueling system to such operating tests as required by the Designer to demonstrate satisfactory functioning and operating performance of the entire fueling system. The jet A fuel system will be visually inspected to ensure that all of the mechanical connections are complete, joints are tightened, all construction activities are complete, and the various equipment supplier recommendations and field installation requirements have been met. The electrical components and instrumentation will also be visually inspected and reviewed versus the drawings and equipment supplier vendor drawings to ensure that all electrical components and instrumentation has been installed as required and that the electrical terminations have been properly completed in accordance with the supplier requirements and drawings.
- 3.2.2.** Inspection, testing and flushing will follow Airlines for America (A4A) 103 – “*Standards for Jet Fuel Quality Control at Airports*” and ASTM D 1655 – “*Specification for Aviation Turbine Fuel.*” Testing of fuel piping will be performed in accordance with ANSI B31.4.
- 3.2.3.** All valves will be individually cycled full- closed to full-open and returned to full- closed to ensure smooth operation with no mechanical binding. Valves will be suitable to hold test pressure for the specified time without leakage.
- 3.2.4.** The Contractor will furnish all necessary equipment, materials and personnel, including pumps, compressors, gauges, testing equipment, gases and fluids, recording equipment, utilities, valves, and craftsmen and all incidentals necessary to test and initially start-up the fuel system. All instruments required to conduct the tests will be furnished and operated by the Contractor using experienced and qualified personnel.
- 3.2.5.** All tests will be witnessed by the Designer, HAS, and the operator.
- 3.2.6.** Piping systems will be tested before backfilling, concealing or covering.
- 3.2.7.** When a system/component fails to meet the requirements of a test, adjustments will be made to the equipment or the defective materials will be removed and replaced, and the system/component retested.
- 3.2.8.** Submit copies of test reports to the Designer and or HAS authorized representative for approval.
- 3.2.9.** Perform holiday testing of coating systems on all piping prior to pressure testing and backfilling.
- 3.2.10.** Submit detailed procedures for flushing and testing methods for approval by the Designer before starting pipe installations. This includes all radiographing, pressure testing, and holiday testing.
- 3.2.11.** Water will not be used for testing or flushing fuel piping.
- 3.2.12.** Sectionalize pipe lines as required to facilitate testing.
- 3.2.13.** Conduct the tests of all systems in a safe manner and correct all deficiencies.
- 3.2.14.** Apply the specified test pressures by means of a pump or compressor connected to the piping off highest elevation.
- 3.2.15.** Be fully responsible for providing qualified and experienced personnel to operate the equipment

throughout the testing and flushing operations.

- 3.2.16.** Obtain all necessary approvals, acceptances, and permits.
- 3.2.17.** Observe diligent care not to waste, spill or contaminate the fuel. The cost of all fuel spilled, wasted or contaminated will be paid for by the Contractor. The Contractor will also be responsible for any and all required soil remediation deemed necessary by the Designer at no additional cost to HAS.

3.3. Training

- 3.3.1.** Prepare and submit Operating and Maintenance Manuals for operating systems and equipment as outlined in Division 1 Contract Specifications.
- 3.3.2.** Instruction manuals will cover the care, preservation, and maintenance of engineered components and systems and architectural products and finishes.
- 3.3.3.** Instruction manuals will provide HAS the fueling system operator instructions on the operation and maintenance of systems and equipment.

30 - STRUCTURAL SYSTEMS



30 - Structural Systems

Part 1 – General

1.1. Overview

1.1.1. This Standard defines general design criteria that apply to the design of structural systems at the Houston Airport System (HAS) Airports.

1.2. Loads

1.2.1. The following special loadings will take precedence over those mentioned in the current Building Code for the special cases mentioned:

1.2.1.1. Live Loads: Live loads will be approved by HAS but at a minimum will comply with the minimum requirements of the code. Live loads will be modified as needed to accommodate additional requirements.

1.2.1.2. Wind Loads

1.2.1.2.1. Basic Wind Velocity: Refer to the COH amendment to the IBC section 1609.3 for ultimate design wind speeds

1.2.1.2.2. Exposure Category: C

1.2.1.3. Wind Loads Airside Face: Wind load for Terminal buildings at the airside face only will be 50 pounds per square foot (psf) applied to any 15 square foot area for components and cladding, per Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5300-13, Chapter 8, *The Effects and Treatment of Jet Blast*. This load need not apply at inset penthouse structures 40 feet above the apron level. This load is a result of aircraft jet blast plus meteorological conditions.

1.2.1.4. Roof Loads: Live loads for roof levels where additional floors will or may be constructed in the future will be 100 psf minimum, or the code-required load for the proposed future occupancy, whichever is greater.

Part 2 – Products

2.1. Material and Unit Stresses

2.1.1. Concrete: Non-prestressed concrete for structural elements will be designed for a minimum 28-day compressive strength (fc') of 4,000 pounds per square inch (psi), or as dictated by design requirements. All concrete exposed to the elements will be designed with 3 percent to 6 percent entrained air. Adequate equipment will be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather.

2.1.1.1. Prestressed concrete for structural elements will be designed for a minimum 28-day compressive strength (fc') of 5,000 psi.

2.1.1.2. Concrete subject to freezing temperatures while wet will have 3.5 percent to 6.5 percent air entrainment at point-of- placement, unless noted otherwise. Admixtures will be used with care and

compatibility will be verified by testing laboratories.

2.1.2. Structural Steel: Structural steel will conform to the following:

- **W, WT Shapes:** American Society for Testing and Materials (ASTM) A 572, Grade 50, ASTM A 992.
- **S, M, HP, and Channels:** ASTM A 36, A 572 Grade 50.
- **Angles and Plates:** ASTM A 36, A 572 Grade 50.
- **Pipes:** ASTM A 53, Grade B.
- **Tubes:** ASTM A500. Grade B.
- **Erection Bolts:** ASTM A 325.
- **High Strength Bolts:** ASTM A 325.
- **Anchor Bolts and Rods:** ASTM A 36, A 307, A 193, F 1554.

2.1.2.1. High Strength Low Alloy (HSLA) Steel:

ASTM A 588 steel will be allowed with

prior approval for high-mast light poles and base plates. HSLA steel will not be used in areas of high moisture or water unless a proper surface treatment is utilized. Concrete pier pedestals for high-mast light poles will be at least 36 inches above finish grade.

2.1.3. Prestressing Tendons: Tensile stress in prestressing tendons due to jacking force shall not exceed 0.94 first pass yield (fpy) (specified yield strength of prestressed tendons), psi. Prestressed members will be designed using 7 wire strand having an ultimate tensile strength of 270,000 psi and conforming to ASTM A-416.

2.1.4. Low relaxation strands may be considered in design if they meet ASTM A421, ASTM A416, and American Concrete Institute (ACI) Building Code 3.5.5 and Commentary.

2.1.5. Reinforcing Steel: All reinforcing steel will comply with ASTM A615 Grade 60 and will be shop fabricated when delivered to the site.

2.1.6. Clear concrete cover on reinforcing will be as follows, unless otherwise shown:

- Concrete cast against and permanently exposed to earth – 3 inches
- Concrete exposed to earth or weather:
 - #6 through #18 bars – 2 inches
 - #5 bar, W31 or D31 wire, and smaller – 1-1/2 inches
- Concrete not exposed to weather or in contact with ground:
 - #14 and #18 bars – 1-1/2 inches.
 - #11 bar and smaller – ¾ inches.
- Beams, columns: Primary reinforcement, ties, Stirrups, spirals – 1-1/2 inches.
- Shells, folded plate members:
 - #6 bar and larger – ¾ inches.
 - #5 bar, W31 or D31 wire, and smaller – ½ inch.
 - Beams and girders - 1-1/2-inch interior, 2-inch exterior.

2.2. Structural Foundation Systems

- 2.2.1. Foundations:** Allowable foundation capacities will be determined from geotechnical investigations under the direction of a professional geotechnical engineer registered in the State of Texas.
- 2.2.1.1. Foundations will be designed to prevent uplift and differential settlement, as well as load bearing requirements.
- 2.2.1.2. Minimum ground cover over footings will be 12 inches.
- 2.2.1.3. The subgrade for all buildings will be pressure injected with lime slurry or Cement Treated Base (CTB). The lime slurry will be pressure injected at least 3 feet beyond the building line. The requirements for injection grid density, depth of injection, additional injections, curing times, and stabilization or pH results will be based upon geotechnical recommendations.
- 2.2.2. Horizontal Framing Systems:** Floor systems at Terminal buildings will be designed to eliminate excessive vibrations from pedestrian and people-mover cart traffic. The design will fall within the slightly perceptible range or better of the foot fall vibration scale.
- 2.2.2.1. Framing systems will be designed considering requirements for future floor openings. Future beam and column connections will not be drilled expansion bolts, but embedments with adequate shear and tensile capacities. Existing beams, columns, walls, and slabs will not be connected with explosive or dry powder inserts.
- 2.2.3. Precast Double-Tees:**
- 2.2.3.1. No bottom connections into legs.
- 2.2.3.2. Side penetrations into legs will utilize pre- drilled holes where possible.
- 2.2.3.3. No powder actuated inserts into legs or decks.
- 2.2.3.4. Existing double-tee roof and floor systems will be evaluated for loads, penetrations, or attachments by a registered structural engineer, licensed to practice in the State of Texas.
- 2.2.4. Detailing:** Detailing for structural steel will comply with the latest edition of American Institute of Steel Construction (AISC) *Detailing for Steel Construction*.
- 2.2.4.1. **Connections:** Steel moment connections will be designed using the Allowable Stress Design (ASD) Specification or the Load and Resistance Factor Design (LRFD) Specification for Structural Steel Buildings.
- 2.2.4.2. Concrete embedments will have sufficient anchorage ties to prevent cracking or rapid failure. Corrosion resisting finishes will be used on all structural embedments.
- 2.2.4.3. All connections, whether designed by the Designer's Structural Engineer, the suppliers, or structural detailers, will be designed and sealed by a professional structural engineer registered in the State of Texas.
- 2.2.4.4. **Openings:** Openings in structural slabs will be detailed such that spalling of concrete edges will be prevented. Diagonal reinforcement will be provided at corners, re-entrant slabs and floor penetrations.
- 2.2.4.5. **Expansion Devices and Materials:** In addition to ACI 318, the Designer must refer to ACI 504.R for various joint treatments, to ACI 224.R, and ACI 224.TR for crack controls.

2.3. Parking Structures

- 2.3.1. Material Selection:** Structural steel will not be considered for the vertical and horizontal framing system unless approved by the HAS Project Manager.
- 2.3.2. Steel:** All exposed miscellaneous steel used for concrete supports and connections will be galvanized and retouched after installation.

- 2.3.3. Corrosion Protection:** Calcium chloride and admixtures containing chlorides must not be used in concrete for parking structures. Admixtures will be used with care, compatibility, and will be verified by testing laboratories.
- 2.3.3.1.** Protection of embedded metals including concrete cover over reinforcement, post-tensioning tendons, pretensioned connections for precast systems, dissimilar metals, and embedded metal conduit must meet or exceed the minimum ACI 318 requirements.
- 2.3.3.2.** ACI 362.1R, *Guide to the Design of Durable Parking Structures*, must be consulted for pertinent information concerning corrosion inhibitors, cathodic protection, and protection of concrete. The guidelines for applied sealers or membrane treatments will be followed.
- 2.3.4. Expansion Devices and Materials:** Expansion joint seals and isolation joints will be designed to prevent the following defects or failures:
- 2.3.4.1.** Migration, bleeding into or staining abutting materials.
- 2.3.4.2.** Deformation sufficient to become unsightly or cause leakage.
- 2.3.4.3.** Chalking, picking up dust or excessive color change.
- 2.3.4.4.** Adhesive or cohesive failures.
- 2.3.4.5.** In addition to ACI 318, the Designer must refer to ACI 504.R for various joint treatments and to ACI 224.R and ACI 224.1R for crack controls.
- 2.3.5. Elastomeric Bearings:** Bearings will be designed as a plain pad with a 70 durometer elastomer or laminated pads with a 60 durometer elastomer.
- 2.3.6. Parapet Systems:** Systems that are integral or monolithic with supporting structural systems will be designed such that damage to the parapet will not adversely affect the supporting system. The use of isolation joints and membrane protection is important at roof connections.
- 2.3.7. Drainage Systems:** Systems will be designed and located such that structural elements (e.g., reinforcing steel, tendons, beam flanges, lighting column base plates) will take precedence. Use the least number of bends for unimpeded flow. Clean outs will be placed at every 100 feet.

2.4. Aircraft Bridge Structures

- 2.4.1.** This Standard will apply to all bridges, tunnels, culverts, vaults, and all other structures supporting aircraft or under runways, taxiways, or aprons. Such structures will conform to the minimum requirements set forth in this Standard and FAA AC 150/5300-13 (latest edition). Unless specifically approved by the City Engineer, all aircraft rated bridges will be structural steel.
- 2.4.2. Airplane Design Group:** Structures at George Bush Intercontinental Airport (IAH) will be designed and proportioned to accommodate Airplane Design Group VI as defined in FAA AC 150/5300-13. Structures at William P. Hobby Airport (HOU) will be designed and proportioned to accommodate Airplane Design Group III. Structures at Ellington Airport (EFD) will be designed and proportioned to accommodate the Design Critical Aircraft.
- 2.4.2.1.** Each element of the structure will be designed to accommodate the most demanding airplane under this design group. This may result in more than one airplane being used in designing a particular structure (e.g., bridge width may be controlled by the airplane with the longest wing span, whereas another airplane may have higher wheel loads, thus controlling beam design).
- 2.4.3. Live Loads:** Structures will be designed for the following airplane loads:
- 2.4.3.1.** Spans less than 2 feet in the shortest direction, including manhole lids and grates - uniform live load of 250 psi.
- 2.4.3.2.** Span lengths 2 to 10 feet in the shortest direction - the greater of a uniform live load varying between

250 psi and 50 psi in inverse proportion to the span length or the maximum number of wheel loads for the airplane which can be applied to the structure.

2.4.3.3. Span lengths greater than 10 feet in the shortest direction — wheel loads for the design airplane.

2.4.4. Impact: For those elements listed in Group A (defined in 2.4.5. below), the live load will be increased by the following percentages. This increase will account for impact loads and vibration:

2.4.4.1. **30-percent:** Parking aprons and low speed taxiways.

2.4.4.2. **40-percent:** High speed taxiways and runways.

2.4.4.3. **100-percent:** Touchdown areas of runways.

2.4.4.4. Live loads will not be increased by impact for those items in Group B (defined below, 2.4.6.):

2.4.5. GROUP A

2.4.5.1. Superstructure, columns and pedestals that support the superstructure with rigid, fixed or expansion bearings, or that are rigidly attached to the superstructure, and legs of rigid frames.

2.4.5.2. The portions above the ground line of piers that are rigidly connected to the superstructure as in rigid frame or continuous structures.

2.4.6. GROUP B

2.4.6.1. Abutments, retaining walls, piers, pile caps, and pilings which are not rigidly connected to the superstructure.

2.4.6.2. Buried foundations, footings and supporting soil, and structures with 3 feet or more of earth cover.

2.4.7. Impact for structures covered with fill will vary from the percentage shown at ground level to 0 percent at a depth of 10 feet.

2.4.9. Braking Force: Longitudinal forces due to braking will be included in the design of all structures subject to direct wheel loads. This braking force will be the following percentages of live load without impact:

2.4.7.1. **30 percent:** Parking aprons and low speed taxiways.

2.4.7.2. **70 percent:** High speed taxiways and runways.

2.4.10. Clearances: Vertical clearances for aircraft bridges over roadways and horizontal clearances to piers from these roadways will be the same as those described in previous sections.

2.4.11. Materials: Construction material specifications, strengths, handling, storage, and testing will comply with the latest version of the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges*.

2.4.12. Design Load Combinations: In addition to live and dead loads, the following loadings will be taken into account:

- Earth pressure
- Buoyancy
- Wind (including jet blast and uplift)
- Shrinkage
- Temperature
- Longitudinal force
- Stream flow
- Construction loads and any special loads. Loads will be applied in such a manner as to produce the maximum stresses.

2.4.11.1. Loading combinations will be the same as those described in latest version of the AASHTO's "Standard Specifications for Highway Bridges," and interim specifications.

2.5. Highway Bridges

- 2.5.1.** This provision will apply to structures with spans greater than 20 feet and whose function is to carry roadway traffic. This section does not apply to parking structures or ramp systems within highway bridges.
- 2.5.2. Specifications:** Highway bridges will be designed in accordance with AASHTO's "*Standard Specifications for Highway Bridges*," with interim specifications.
- 2.5.3. Live Loads:** All bridges on arterial roads will be designed for an HS20-44 live load plus impact.
- 2.5.3.1.** Bridges along secondary roads will be designed for an HS20-44 live load plus impact unless waived by the City Engineer, in which case the design live load will be HS15-44 plus impact.
- 2.5.4. Bridge Widths:** Generally, bridge width from face of rail to face of rail will be at least as wide as the approach roadway's usable shoulder.
- 2.5.5. Clearances:** For horizontal and vertical clearance requirements, see Obstruction Clearances within this Standard.
- 2.5.6. Materials:** This section will govern materials used in the construction of highway bridges and incidental items relating to these structures.
- 2.5.6.1. Concrete:** Concrete materials, quality, classes of, and proportioning will comply with the applicable sections of the Texas Department of Transportation (TxDOT) "*Standard Specifications for Construction of Highways, Streets, and Bridges*".
- At the discretion of the City Engineer, construction specifications may be taken from "*Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic*", latest edition, published by the City of Houston (COH) Department of Public Works and Engineering, except as modified herein. No variance from these specifications or the modifications herein may be made without the approval of the City Engineer for the HAS (referred to throughout as the City Engineer).
- 2.5.6.2. Structural Steel:** Structural steel, forgings, castings, anchor bolts, pipe, tubing, bolting of and welding of will comply with the applicable sections of the TxDOT "*Standard Specifications for Construction of Highways, Streets, and Bridges*".
- 2.5.6.3. Reinforcing Steel:** Reinforcing steel material and bending will comply with the applicable sections of the TxDOT "*Standard Specifications for Construction of Highways, Streets and Bridges*".
- 2.5.6.4. Prestressing Steel:** Prestressing steel, packing, storing, handling, working drawings, and construction methods will comply with the applicable sections of the TxDOT "*Standard Specifications for Construction of Highways, Streets, and Bridges*".
- 2.5.7. Materials:** Construction material specifications, strengths, handling, storage, and testing will comply with the TxDOT "*Standard Specifications for Construction of Highways, Streets and Bridges*".
- 2.5.8. Design Loads and Loading Combinations:** The minimum live load will be 100 psf. Where equipment and small vehicles are anticipated to use this structure, live loads will be increased accordingly.
- 2.5.9.** In addition to live and dead loads, the following loadings will be taken into account: earth pressure, buoyancy, wind (including jet blast and uplift), shrinkage, temperature, stream flow, construction loads and any special loads. Loads will be applied in such a manner as to produce the maximum stresses.
- 2.5.10.** Loading combinations will be the same as those described in AASHTO's "*Standard Specifications for Highway Bridges*", and interim specifications.
- 2.5.11. Clearances:** Vertical clearances over roadways will be 1 foot greater than outlined in within this Standard.

2.6. Retaining Walls

- 2.6.1.** Retaining wall design and materials will comply with applicable sections of the Building Code and the geotechnical investigation report for that project.
- 2.6.2.** The effect of wall movement due to expansive soils will be taken into account. When necessary, appropriate design steps will be taken to minimize the effects.
- 2.6.3.** The factor of safety for overturning will be 1.5 minimum and 2.0 maximum. The factor of safety for sliding and circular soil arc failure will be a minimum of 1.5. Expansion joints will be provided every 90 feet maximum and contraction joints every 30 feet maximum.

2.7. Tunnels

- 2.7.1.** Tunnels will include all below grade, enclosed structures used by pedestrians, vehicles, or to hold utilities.
- 2.7.2.** Due to the varied applications of tunnels, the design criteria will be established on a project-to-project basis.
- 2.7.3.** Items of particular interest that must be addressed are: waterproofing, ventilation, lighting and utilities, drainage, exiting, fire protection, cathodic protection/corrosion control, and overburden loading.

2.8. Crosswalks

- 2.8.1.** All crosswalks installed in terminal curbsides, either arrival or departure, where passengers must cross lanes that have moving traffic will be equipped with in-pavement lights attached to a sensor so that the lights operate when a pedestrian is in the crosswalk.

Part 3 - Execution (Not Used)

31- AIRFIELD DESIGN



31 - Airfield Design

Part 1 – General

1.1. Scope and Purpose

- 1.1.1.** Airside Projects or project components include all areas located inside the Air Operations Area (AOA) or areas that affect air navigation. The design and construction of Airside Projects must follow, at a minimum, the standards prescribed in the various Advisory Circulars (AC) from the Federal Aviation Administration's (FAA) standards for airport design. Use of the FAA ACs are mandatory for all projects funded by federal grant monies through the Capital Improvement Program and/or with revenue from the Passenger Facility Charges (PFC) Program to ensure certification of the Houston Airport System (HAS) as part of Title 14 Code of Federal Regulations (CFR) Part 139, Certification of Airports, subparts C (Airport Certification Manual) and D (Operations).
- 1.1.2.** Although the FAA ACs are not mandatory for non-FAA funded or non-PFC funded projects, including Tenant Improvement Projects (TIP), the Designer must follow the minimum requirements put forth in the ACs for all work within the AOA and on tenant apron/Hangar pavement areas to ensure compliance with the Part 139 requirements. Where the FAA ACs do not provide direction for Project components the Designer must coordinate with the HAS Project Manager to verify the appropriate standards to use. The Designer must attain approval in writing from the HAS Project Manager of the approved design standards prior to commencing design. Any fees related to design changes resulting from using non-approved design standards must be borne by the Design Consultant, or as specified in the consultant contract.

1.2. Federal Aviation Administration (FAA) Standards

- 1.2.1.** These standards may be obtained from the Federal Aviation Administration, Post Office Box 1689, Fort Worth, Texas 76101; U. S. Department of Transportation, Subsequent Distribution Section, M-4943, Washington, D.C. 20590; Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402; or other FAA regional offices. FAA standards and forms are available through the FAA website www.faa.gov.
- 1.2.2.** In some instances, portions of a Project or a Project Component may not fall under the scope of the FAA ACs, even though the Project may reside inside the AOA. For instance, public waterlines may be part of an airside project for which the FAA may have no AC covering the design and construction or relocation of the utility. In these instances, the Designer must recommend the appropriate design standard and/or specification to the HAS Project Manager for written approval. The Designer must follow state and local (Texas Department of Transportation [TxDOT] and City of Houston [COH]) standards. The Designer will receive written approval from the HAS Project Manager prior to commencement of design. Since all the HAS Airports reside in the City of Houston and/or Harris County, the typical appropriate design standards and specifications that will serve in-lieu of FAA standards are provided by COH and Harris County. Refer to Landside Civil Design Standards for more information.

1.3. General Provisions

- 1.3.1. General Information:** This section covers all applicable facilities within the AOA and tenant apron/Hangar pavement areas that will be planned, designed and constructed in accordance with current FAA standards and criteria. These consist of current editions of the Federal Aviation Regulations (FARs) and ACs. Copies may be obtained from the FAA Southwest Regional Office and U.S. Department of Transportation.
- 1.3.2. Design Criteria:** In some cases, the ACs offer the Designer a range of criteria. In this case, this Design Standard Manual will establish minimum standards to be used at the HAS Airports. If design criteria decisions must be made that are not covered in the respective AC or this Manual, the Project Designer must make recommendations to the City Engineer on a case-by-case basis. The Design Consultant must submit three alternate designs and recommend options for HAS to consider.
- 1.3.3. Airfield Lighting:** Airfield lighting must meet the current edition of FAA AC 150/5340-30, *Design and Installation Details for Airfield Visual Aids* and other related ACs. refer to applicable sections within this Standard, under Section 3 Electrical, Exterior Lighting for general electrical service requirements.
- 1.3.4. Critical Design Aircraft:** The Critical Design Aircraft (CDA) must be identified for each project per the current edition of FAA AC 150/5000-17, *Critical Aircraft and Regular Use Determination*; however, the standard for the George Bush Intercontinental Airport (IAH) is Aircraft Approach Category D (AAC), Airplane Design Group VI (ADG), and Taxiway Design Group 6 (TDG) per FAA AC 150/5300-13, *Airport Design*, except when dealing with existing facilities that are designed to a lesser standard, and the HAS City Engineer confirms that the lesser standard must be maintained. Use of the existing standard must be approved on a case-by-case basis. The standard for William P. Hobby Airport (HOU) is AAC C, ADG III, and TDG 3. For Ellington Airport (EFD), the CDA will depend on the facility being addressed. For TIP projects, tenants must submit a list of aircraft they anticipate serving and the CDA used for design calculations, including expected annual departures. The final decision on the applicable CDA rests with the HAS City Engineer. Changes from this standard may be made pertaining to any of the following elements:
- 1.3.4.1. Runway Length:** The runway length must be based on the takeoff and landing characteristic of the CDA and the airport- specific characteristics that affect aircraft performance, per the current edition of FAA AC 150/5300-13 and AC 150/5325-4, *Runway Length Requirements for Airport Design*. Runway lengths must conform to the current approved Airport Layout Plan (ALP) unless a revised length is approved by HAS Planning and the HAS City Engineer.
- 1.3.4.2. Width, Clearances and Separations of Runways, Taxiways and Parking Aprons:** The associated Airplane Design Group per AC 150/5300-13 for the CDA, will be recommended by the Designer based on traffic forecasts from the current master plan update or Tenant Airline.
- 1.3.4.3. Pavement Design:** The design must be based on the current edition of FAA AC 150/5320-6, *Airport Pavement Design and Evaluation*.
- 1.3.5. HAS Approval of Design Criteria:** Review by the HAS City Engineer in conjunction with the General Manager of the subject airport of all AOA ADG standards must be accomplished prior to final design.
- 1.3.6. Geometrics:** All airfield geometry must conform to the current Airport Layout Plan (ALP) and adhere to all appropriate FAA ACs. Detailed geometry not included or referenced on the ALP must conform to the requirements in the ACs specific to the requirements of the Project and/or specific airport.
- 1.3.7. Line of Sight:** All runways and runway safety areas must conform to the line-of-sight criteria of FAA AC 150/5300-13. Taxiways under the control of the Air Traffic Control (ATC) Towers must be in full view of the tower cab full length and width. An ATC Tower Line- of-Sight (Shadow) Study must be prepared to determine the line-of-sight acceptability. Ramp control towers, where applicable, may require line-of-sight studies for aircraft parking areas and taxilane intersections.

- 1.3.8. Airspace Requirements:** All projects on the airport require an Obstruction Evaluation/Airspace Analysis by FAA to determine if the permanent structure or contractor temporary activities pose an impact to the navigable airspace and NAVAIDS. Prior to commencement of airfield construction, a FAA Form 7460 must be completed with appropriate information and exhibits required by the FAA on which FAA can conduct an Aeronautical Study of the proposal in accordance with the latest FARs. Non- AOA projects will require an Airspace Form for staging areas, batch plants, construction cranes and other related items. Construction activities (temporary stationary objects) will be reviewed through the Airports Local Airspace Review Program administered by HAS. Designer must coordinate filing of all 7460s through HAS's Airspace Coordinator.
- 1.3.8.1.** No construction activity will commence until the Airspace Study is completed and comments have been incorporated into the project drawings and specifications and an Airspace Determination Letter is received from FAA with Approval or Conditional Approval.
- 1.3.8. Gradients and Slopes:** All paved and turfed areas on the airfield AOA must conform to the requirements of AC 150/5300-13, and as supplemented by the following criteria:
- 1.3.8.1.** Side slopes on excavation (cut) and embankment (fill) areas outside of runway and taxiway safety areas must have a slope no steeper than four horizontals to one vertical (4H:1V).
- 1.3.8.2.** The standard crowns (transverse slope) on runways and taxiways must be one percent, except where flatter grades are necessary due to intersection transitions, in which case they must be a minimum of 0.5 percent.
- 1.3.8.3.** All paved runway shoulders and taxiway shoulders must be paved with a minimum of one percent to a maximum of five percent surface gradient. The desirable slope is two percent. The maximum slope must not be used without approval of the HAS City Engineer. The edge of pavement to edge of shoulder conform joint must be at the same elevation (no pavement lip).
- 1.3.9. Site Preparation for NAVAIDS:** Design criteria for NAVAID critical areas must conform to FAA AC 150/5300-13 and applicable FAA Joint Orders (JO) for NAVAIDS to be constructed. FAA NAVAIDS access roads must be a minimum of 10 feet wide. To prevent vehicle tires from tracking Foreign Object Debris (FOD) onto runways and taxiways, the first 300 feet (91 meters) adjacent to a paved operational surface must be paved.
- 1.3.10. Deicing Facility:** All deicing requirements must conform to FAA AC 150/5300-14, *Design of Aircraft Deicing Facilities*.
- 1.3.11. Safety and Security during Construction:** The Designer must coordinate with HAS Airside Operations through the Project Manager regarding all safety and security provisions of the Project. Other considerations, depending on the project scope, include interim or temporary pavement marking and lighting and required Special Provisions to fit the Project.
- Provisions must be made for and included in all contract documents pertaining to safety during construction, construction sequencing, access to the site, Contractor's staging area, haul routes, concrete wash out area, project scales, barricades, fencing, traffic control, etc. The current edition of FAA AC 150/5370-2, *Operational Safety on Airports During Construction*, FAA Southwest Regional Order 5200.11, and HAS Operational Instructions for Maintenance and Construction on the AOA contains the means by which construction may be accomplished within the AOA.
- 1.3.11.1.** The Designer must develop the Construction Safety Phasing Plan (CSPP) for each on-airfield construction project and TIP project on the AOA under the guidelines of AC 150/5370-2 or latest edition for review and approval by Airside Operations. The Designer must include a note in the contract documents for the Contractor to prepare the Safety Plan Compliance Document (SPCD), which details how the Contractor will comply with the CSPP and all applicable Safety and pertinent Security requirements for the Project.

1.3.12. Permitting: A construction permit will be required for all airfield construction projects. Prior to construction, the Designer or Contractor will be responsible for ensuring each project permit application is completed and filed with the HAS Building Standards Group. For information about the permit application submittal procedure can be found at www.fly2houston.com. Utility connections are permitted through COH Public Works.

Part 2 – Products

2.1. Earthwork

2.1.1. Soil Investigations: A review of existing soils information must be performed to initiate any field investigations. The existing information must be used to develop a general soils profile for a preliminary geotechnical analysis. The subsurface investigation must consist of an adequate number of soil borings per the standards. Boring locations must be selected based on the specific plans for the proposed excavation, accessibility of the drilling equipment, and information obtained during the review of the existing soils information in accordance with the current edition of FAA AC 150/5320-6, *Pavement Design and Evaluation*.

2.1.2. Subgrade, Soils, and Pavement Testing Investigation Program: Each Project Designer must prepare a recommended soils program for the HAS review and acceptance. A final Geotechnical Investigation Report must be submitted with the final construction documents and included as an appendix to the Project Design Report. The Geotechnical Investigation Report must include the following information at a minimum:

- 2.1.2.1. Water table information (drilling depth- until water table is encountered);
 - 2.1.2.2. Design California Bearing Ratio (CBR) and Soil Modulus (E) for subgrade soils to be used in the pavement design;
 - 2.1.2.3. Testing report for collapsible soils;
 - 2.1.2.4. Testing report for soils resistivity analysis (chloride and sulfate content) for corrosion potential;
 - 2.1.2.5. Soils dispersion test, if applicable, to determine and evaluation of dispersive clay in the soils
 - 2.1.2.6. Fault line map for EFD and HOU;
 - 2.1.2.7. Sub-surface utility engineering (SUE) must be incorporated in the design as to minimize potential risk arising from underground conflict utilities around the airport projects,
 - 2.1.2.8. **Geotechnical Drilling Safety notes:** Consultant/Contractor is responsible for any damage to existing utilities/structure due to coring/ drilling activities around the airports during Geotechnical investigation or project construction.
- 2.1.3. Subgrade Treatment:** All subgrade must be treated either by Lime/Fly ash, Cement/Fly ash or Lime- Cement –Fly ash stabilization based on the soils report. The thickness and quantity of the stabilized material must be specified in the soils report submitted by the Project Designer/Geotechnical Engineer as a part of project submittal and be based on past experience in similar projects or through series of laboratory tests. Design criteria must conform to the current edition of FAA AC 150/5320-6. Placement of the Lime/Fly ash, Cement/Fly ash or Lime-Cement-Fly ash must be placed in slurry form. Cement slurry or pelletized lime may be allowed depending on soil characteristics and specific site condition.

2.2. Flexible Base Courses

2.2.1. Subbase Treatment: All flexible base must be P-209 or P-219 Crushed Aggregate Base Course in accordance with FAA AC 150/5370-10, *Standard Specifications for Construction of Airports*. All new full-strength pavements must include a 2-inch minimum lift of P-401 Asphalt Mix used as a bond breaker/leveling course directly underneath the P-501 Cement Concrete Pavement. Any exception to using a leveling course or an asphalt material as a bond breaker must be approved by the City Engineer. Design criteria to conform to FAA AC 150/5320-6 or latest edition.

2.3. Rigid Base Courses

2.3.1. Subbase and Base Course: All full-strength airfield pavements must include P-304 Cement Treated Aggregate Base Course or P-306 Lean Concrete Base Course. Design criteria must conform to the current edition of FAA AC 150/5320-6.

2.4. Flexible Surface Courses

2.4.1. Asphalt Pavement: Asphalt pavement must not be used on airfield pavement except as blast protective pavement on shoulders and blast pads and certain pavements at HOU and EFD as recommended by the Designer and approved by the City Engineer. Mix design proportions and criteria may be either FAA P-401 (AC 150/5370-10) or TxDOT Specification No. 340 with specific approval of the City Engineer. All joints between concrete and asphalt must be sawed and sealed to retard moisture intrusion and vegetation growth. Design criteria must conform to FAA AC 150/5320-6 or latest edition.

2.5. Rigid Pavement

2.5.1. Pavement Design: Pavement design for all aircraft rated pavements must be based on FAA methodology and requirements in FAA AC 150/5320-6 or the latest published edition. The FAARFIELD software must be used in the primary design method for airfield pavements. Alternate design methods can be used as a design check only. Any difference between the FAARFIELD and other design procedures must be fully explained and reconciled in the Project Design Report. The Project Design Report must also describe correlations between subgrade strength characteristics with supporting documentation. The Pavement Project Design Report must also include:

2.5.1.1. ACN/PCN and ACR/PCR numbers for new runway/ taxiway pavement (after construction) using the current version of COMFAA. The Designer must use nondestructive testing techniques to evaluate the pavement and a detail analysis must be included in the report that will be submitted to the FAA.

2.5.1.2. Provide the layered modulus information for newly constructed pavement (runways/taxiways/apron) after construction using nondestructive testing data.

2.5.1.3. **Sensitivity Analysis:** All designs must include a sensitivity analysis to quantify the effects of variations in the selected input values on pavement design thickness. At a minimum, the sensitivity analysis must be based on variations from the following input.

2.5.1.3.1. Aircraft frequency: Source Airport Master Plan Update

2.5.1.4. Fleet Mix, Critical Design Aircraft (CDA), and annual departures and growth rate.

- 2.5.1.5. Geotechnical Investigation Report
- 2.5.1.6. FAA Form 5100-1, Airport Pavement Design
- 2.5.2. Fine Aggregate:** Test for fine aggregate for concrete must be done per Tex-203-F sand equivalent test, in addition to FAA requirements.
- 2.5.3. Shoulders and Blast Pads:** Shoulder and blast pad pavements design must be recommended by the Designer and approved by the City Engineer based on the need to support the occasional passage of the most demanding aircraft as well as maintenance and emergency response vehicles. The shoulders and blast pads must be of the same thickness and must be designed in accordance with the current FAA FAARFIELD software.
- 2.5.4. Non-Aircraft Pavement:** Non-aircraft areas include emergency (Aircraft Rescue and Fire Fighting [ARFF]) roads, tenant (tug) roads and other service roads that must conform to the TxDOT Roadway Design Manual and Standard Construction Specifications.
 - 2.5.4.1. **Airside Vehicular Access Roadway:** Roadway may be designed using the TxDOT Roadway Design Manual and Standard Construction Specifications so long as the most demanding ARFF vehicle is used as the design vehicle. Aircraft tug equipment will also be considered when appropriate.
 - 2.5.4.2. **ARFF Roads**
 - 2.5.4.2.1. This pavement section is to follow the TxDOT and the COH roadway standards.
 - 2.5.4.2.1. **Load Limits:** The minimum vehicle load limit for Fire Apparatus Access Roads is 53,000 pounds. The minimum vehicle load limit for AOA fire apparatus access roads is 113,000 pounds. All bridges and elevated roads must conform to this requirement.
 - 2.5.4.2.2. **Turning Radius:** The external turning radius (wall to wall) must not be less than 57 feet. The internal radius must be no less than 35 feet. The turn at no time must be less than 22 feet wide.
 - 2.5.4.2.3. **Grade:** The maximum grade change of any portion of a fire apparatus access road must not exceed 10 feet of rise per 100 feet of run.
 - 2.5.5. Pavement Design Life:** All airfield pavement must be designed with a 30-year structural design life determined by the computer program FAARFIELD. FAARFIELD will provide the required thickness of the rigid pavement slab required to support a given airplane traffic mix for the structural design life over a given base/subbase/subgrade.
 - 2.5.6. Pavement Type:** All airfield pavements must be rigid Portland Cement Concrete (PCC) pavement, except blast protective pavement shoulders and blast pads unless otherwise approved by the City Engineer. Pavement type will be based on technical and economic considerations. The Designer will determine final pavement section based on field investigation, samples, calculations and the current FAA pavement design criteria requirements.
 - 2.5.6.1. **Pavement Strength:** PCC must be designed based on 700 pounds per square inch (psi) flexural strength at 28 days. All full-strength pavements must be reinforced with steel and contain steel reinforcing designed to accommodate the effects of temperature per the standard. Keyways will not be allowed.
 - 2.5.6.2. **Skid Resistance:** All airfield pavements must be designed to provide surface friction and drainage qualities that will promote good traction in all weather conditions. The runways and high-speed taxiways must have a burlap drag finish with saw cut grooves installed. The taxiways and aprons must have a textured finished by using a heavy broom drag, artificial turf drag, transverse brooming, or other approved micro-texture.
 - 2.5.7. Pavement Typical Sections:** Pavement section must be designed in accordance with the current edition of FAA AC 150/5320-6. Standard sections exist for the various aircraft pavements encountered at the HAS Airports. Deviation from these standard sections requires the submittal of a pavement report prepared by a qualified geotechnical and materials engineering firm and a pavement section design sealed by a professional engineer registered in the State of Texas.

2.5.8. Embedded Steel for Crack Control: Concrete slabs must be designed to contain embedded steel reinforcing bars or welded wire mats for crack control per the standard. Any exception to this requirement must be approved by the City Engineer. The thickness requirements for reinforced concrete pavements are the same as plain concrete and as determined by the program FAARFIELD.

2.5.9. Pavement Joint Spacing and Joint Types

2.5.9.1. Joint Layout: Joint layout and spacing must conform to FAA AC 150/5320-6 based on PCC thickness. The joint layout spacing for new rigid concrete panels must be no greater than 20 feet by 20 feet. All concrete panel joints must be steel reinforced. All concrete panels must have 0.050 percent steel reinforcing in both directions to limit cracking. Any exception to this requirement must be approved by the City Engineer. A PCC-hot mix asphalt concrete (HMAC) joint must be used at all locations where the concrete pavement meets the asphalt shoulder.

2.5.10. Runway Exits

2.5.10.1. High Speed Exit Taxiway: Locations must be as shown on the Airport Layout Plans (ALPs). The geometric layout must either match existing high-speed exit taxiways on the airport or conform to FAA AC 150/5300-13. Larger-than-standard fillet radii must be investigated where traffic “back turns” are anticipated.

2.5.10.2. Runway and High-Speed Exit Taxiway Grooving: All runway and taxiway grooving must conform to FAA AC 150/5320-12, *Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces*. Slurry from sawing must be vacuumed as part of the sawing operation and disposed of off the airport property. Final cleanup must include flushing by water.

2.5.11. Aprons: Where holding aprons are included in the Project scope, the overall location and geometric layout must be in accordance with all applicable FAA AC.

2.5.11.1. Aircraft parking aprons will be based on an “Apron Utilization Plan.” Apron utilization criteria, including wingtip clearance, must be approved by the HAS City Engineer or General Manager and must be within the maneuvering limits of the Aircraft Characteristics Manual of the Critical Design Aircraft.

2.5.11.2. Fuel Pits: Fuel Pits must be designed and installed in a manner that transfers any structural loads (vertical/ horizontal) directly to the ground to protect fuel pit canisters from such load related distresses. Aircraft service pits must be located to minimize impact on PCC pavement joint performance.

2.6. Miscellaneous

2.6.1. Pavement Markings: All airfield pavement markings used for providing guidance and visual information to aircraft pilots must be designed in accordance with FAA AC 150/5340-10 Standards and Specification for Airport Markings

2.6.1.1. Paint: Paint must be Waterborne meeting the requirements of Federal Specification TT-P-1952E, Type II.

2.6.1.1.1. Permanent paint markings on new pavements require two coats of paint and contain reflective glass beads. Type III beads are preferred. Glass beads must be applied with the second coat of paint.

2.6.1.2. Preformed Thermoplastic Markings (PTM): Pavement marking on taxiways and aprons, including Surface Painted Holding Position Signs (SPHPS) may be thermoplastic marking as per the requirements of FAA AC 150/5370-10 and FAA Memorandum dated 1/6/2017 (see Exhibit 11-1). The use of thermoplastic marking must be justified through a life-cycle cost analysis.

Exhibit 11-1: Performed Thermoplastic Markings Memo

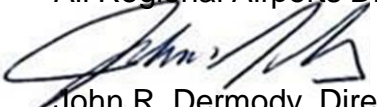
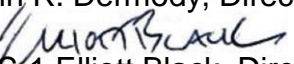


Federal Aviation Administration

Memorandum

Date: JAN 06 2017

To: All Regional Airports Division Managers

From:  John R. Dermody, Director of Airport Safety and Standards,
 Elliott Black, Director of Airport Planning and
Programming, APP-1

Subject: Performed Thermoplastic Airport Pavement Markings

This memorandum clarifies the guidance regarding the use of Performed Thermoplastic Markings (PTM) issued on August 9, 2016. These recommendations will be re-evaluated upon completion of the paint durability study currently underway by the FAA's Office of Aviation Research, Airport Technology Research and Development Branch.

When supported by a life cycle cost analysis, as outlined in FAA Order 5100-38, Airport Improvement Program Handbook, projects funded with Airport Improvement Program (AIP) or Passenger Facility Charges (PFC) funds may include the use of PTM at the following locations:

- ✓ Surface Painted Hold Sign Markings;
- ✓ Taxiway Direction and Location Markings;
- ✓ Geographic Position Markings;
- ✓ Vehicular Roadway Markings on Airfield;
- ✓ Zipper Lines, and
- ✓ Taxiway Edge Lines.

When using PTM particular attention should be paid to surface preparation, application of sealer and timely application of heat in accordance with the manufacturer application guidelines.

Exhibit 11-1: Performed Thermoplastic Markings Memo (Continued)

2

Background

The FAA has been studying the use of PTM since 2006 and markings have been installed at over 188 locations since that time. In general, the PTM markings have performed well, however some locations have experienced localized premature performance issues primarily related to de-bonding to Portland Cement Concrete Pavement (PCCP) and/or distortion under aircraft tires while turning. At all locations that experienced performance issues, the manufacturer has been able to successfully complete warranty repairs or replace the marking with a different marking material.

At some locations PTM markings have been distorted and or displaced under tires and required remedial repairs. Airports should monitor the performance of existing PTM installed at:

- ✓ hold lines;
- ✓ enhanced taxiway centerlines;
- ✓ near high speed exits;
- ✓ at locations where multiple aircraft sit idling, or
- ✓ where sharp nose gear turns are executed.

The current performance issues relate to material not performing as long as anticipated in the life cycle cost analysis, not that the material does not provide markings that provide the visual guidance intended. The performance of any airport markings is dependent upon many factors including: surface condition and preparation prior to application of marking, weather conditions at time of application, proper application methods by the installer, amount and nature of traffic on markings. No airport marking will perform without proper surface preparation, proper materials and proper installation means and methods.

If you have any questions, please contact: Doug Johnson at (202) 267-4689 or by email at Doug.Johnson@faa.gov.

- 2.6.1.3. **Reflective Media:** This feature will be provided by the addition of glass spheres to the surface of the pigmented binder.
- 2.6.1.3.1. Glass beads for white and yellow paint must meet the requirements for Federal Specification TT-B-1325D [Type I, Gradation A] [Type III] [Type IV, Gradation A].
- 2.6.1.3.2. Glass beads for red and pink paint must meet the requirements for Federal Specification TT-B-1325D [Type I, Gradation A] [Type IV, Gradation A].
- 2.6.1.3.3. Glass beads must be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.
- 2.6.1.3.4. Glass beads must not be used in black and green paint.
- 2.6.1.3.5. Type III glass beads must not be used in red and pink paint.
- 2.6.1.4. **Removal:** Removal of pavement markings must be by water blasting or other FAA acceptable means approved by the Project Manager that do not harm the pavement. For short term construction phases, temporary black out of striping will be allowed with the approval of Airside Operations. The use of chemicals for removing pavement markings will not be permitted.
- 2.6.1.4.1. Contract documents must denote the Contractor is responsible for scaring, etching or raveling of pavement caused by excessive removing of markings and must repair all pavements in coordination with HAS prior to reopening to aircraft traffic.
- 2.6.2. Dust control preventive measures during construction must be included in the project documents for airside projects.

2.7. Drainage

- 2.7.1. **Underdrains:** An underdrain/edge drain system is required on all pavement sections unless recommended otherwise by the Designer and approved by the City Engineer. If underdrains are not recommended, the Designer must submit the basis on which they are not recommended to the City Engineer for approval. System layout, elements, and design must be based on soils investigation results, pavement function, and other relevant factors and parameters.
- 2.7.2. **Aircraft Bridge Structures:** This section must apply to all bridges, tunnels, culverts, vaults and all other structures supporting aircraft or under runways, taxiways or aprons. Such structures must conform to the minimum requirements set forth in this Manual and the current edition of FAA AC 150/5300-13). Unless specifically approved by the City Engineer, all aircraft rated bridges must be structural steel.
 - 2.7.2.1. **Airplane Design Group:** Structures at IAH must be designed and proportioned to accommodate Airplane Design Group VI as defined in FAA AC 150/5300-13. Structures at HOU must be designed and proportioned to accommodate Airplane Design Group III. Structures at EFD will be designed and proportioned to accommodate the CDA.
 - 2.7.2.1.1. Each element of the structure must be designed to accommodate the most demanding airplane under this design group. This may result in more than one airplane being used in designing a particular structure (i.e., bridge width may be controlled by the airplane with the longest wing span, whereas another airplane may have higher wheel loads, thus controlling beam design).
 - 2.7.2.2. **Live Loads:** Structures must be designed for the following airplane loads:
 - 2.7.2.2.1. Manholes and inlets must be designed for aircraft rated loading following the applicable FAA AC. Spans less than 2 feet in the shortest direction, including manholes lids and grates - uniform live load of 250 psi.
 - 2.7.2.2.2. Span lengths 2 to 10 feet in the shortest direction - the greater of a uniform live load varying between 250 psi and 50 psi in inverse proportion to the span length or the maximum number of wheel loads for the airplane that can be applied to the structure.
 - 2.7.2.2.3. Span lengths greater than 10 feet in the shortest direction - wheel loads for the design airplane.

2.7.2.3. Impact: For those elements listed in Group A (defined below), the live load must be increased by the following percentages. This increase will account for impact loads and vibration:

- 2.7.2.3.1. 30 percent - Parking aprons and low speed taxiways
- 2.7.2.3.2. 40 percent - High speed taxiways and runways
- 2.7.2.3.3. 100 percent - Touchdown areas of runways
- 2.7.2.3.4. Live loads will not be increased by impact for those items in Group B (defined below):

Group A

- 2.7.2.3.4.1. Superstructure, columns and pedestals that support the superstructure with rigid, fixed or expansion bearings or that are rigidly attached to the superstructure, and legs of rigid frames.
- 2.7.2.3.4.2. The portions above the ground line of piers that are rigidly connected to the superstructure as in rigid frame or continuous structures.

Group B

- 2.7.2.3.4.3. Abutments, retaining walls, piers, pile caps and pilings that are not rigidly connected to the superstructure.
- 2.7.2.3.4.4. Buried foundations, footings and supporting soil, and structures with 3 feet or more of earth cover.
- 2.7.2.3.5. Impact for structures covered with fill will vary from the percentage shown at ground level to zero percent at a depth of 10 feet.

2.7.2.4. Braking Force: Longitudinal forces due to braking must be included in the design of all structures subject to direct wheel loads. This braking force must be the following percentages of live load without impact:

- 2.7.2.4.1. 30 percent - Parking aprons and low speed taxiways
- 2.7.2.4.2. 70 percent - High speed taxiways and runways
- 2.7.2.5. **Clearances:** Vertical clearances for aircraft bridges over roadways and horizontal clearances to piers from these roadways must be the same as those described in Obstruction Clearances.
- 2.7.2.6. **Materials:** Construction material specifications, strengths, handling, storage and testing must comply with the latest version of the American Association of State Highway and Transportation Officials (AASHTO) "Standard Specifications for Highway Bridges."
- 2.7.2.7. **Design Load Combinations:** In addition to live and dead loads, the following loadings must be considered: earth pressure, buoyancy, wind (including jet blast and uplift), shrinkage, temperature, longitudinal force, stream flow, construction loads and any special loads. Loads must be applied in such a manner as to produce the maximum stresses.
- 2.7.2.7.1. Loading combinations must be the same as those described in latest version of the AASHTO's "Standard Specifications for Highway Bridges," and interim specifications.

2.8. Grading

2.8.1. All grading requirements and longitudinal and transverse slope criteria must be in strict conformance with the FAA Airport Design Standards and Specifications.

2.8.1.1. Grading must be planned so that drainage inlets can be placed normally at the edges of the safety areas or in the area midway between the runway and parallel taxiway safety areas. To promote airfield drainage and facilitate long-term maintenance operations, Designers are encouraged to use maximum pavement cross sectional and infield grading slopes where practical. To mitigate ponding on airfield pavements, avoid using minimum slopes unless required for pavement tie-ins, etc.

2.8.1.2. Beyond the edges of pavement, the slopes must be in accordance with the design recommendations for promoting positive drainage and overland flow. In setting grades for areas outside of pavements, the soil characteristics must be considered so as to avoid ponding, erosion and promote infiltration. The Designer must evaluate the grading area requirements such that the location of drop-offs, drainage structures, and swales does not impact future airport development. Designer plans must specify to Contractors in detail the required pavement/ turf edge drop and rough/fine grading requirements for project completion.

2.9. Fencing

2.9.1. Any fence to be installed as AOA Security/Wildlife Exclusion fence will require a Security Amendment and must comply with the applicable HAS Security requirements.

2.9.2. Any fence adjacent to aircraft movement areas must have obstruction lights.

2.9.3. AOA fencing may be required to have privacy mesh installed depending on the location.

2.9.4. AOA fencing must be constructed in locations adjacent to the AOA with no openings or gaps. Gaps of 2-inches below gates are allowable.

Use and Section	Nominal Outside Diameter (Inches)	Nominal Weigh per Foot (+/-10% Tolerance)	
		Type I	Type II
End corner and pull posts			
Fabric height and 6'0", round	2.375	3.65	3.12
square	2.00	2.60	
Over 6'0", round	2.875	5.79	4.64
square	2.50	5.10	
Rails and post braces	1.66	2.27	1.83

Intermediate Posts for Fabric Heights	Nominal Outside Diameter (inches)	Normal Weight per Foot (+/- 10% Tolerance)	Normal Weight per Foot (+/- 10% Tolerance)
6'-0" and less, round	1.90	2.72	2.28
'C' Section	1.872	2.28	2.28
Over 6'-0", round	2.375	3.65	3.12
'C' Section	2.25	2.64	2.664

2.9.5. Leased property fencing is the responsibility of the Tenant and must be aesthetically pleasing. Chain-link fence on leased property must be screened with plantings where appropriate. Planting materials must be approved by HAS and no fruit bearing ornamental trees will be permitted.

- 2.9.6.** Fence must be 8 feet in height of number 10 gauge, 2-inch black PVC coated steel chain link mesh with 3 strands of number 12-gauge, four-point barbed wire mounted above the fence with an outward extension of 45 degrees. Any water crossings or outfalls must have coverage equal in strength and durability to the actual fence. Post must be installed on 10-foot centers maximum. Post, rails and braces must be black PVC coated steel.
- 2.9.7. Gate Locks** – All new unmanned AOA gates must be equipped with an electronic card reader system and must comply with CFR 49, Section 1542.207. Regulations are available at <http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=201049>. Designer needs to check with the HAS Project Manager to determine the currently approved equipment. Currently there are manually operated AOA gates. If the Designer is directed by the HAS Project Manager to install a new manually operated gate without an electronic card reader, a key/padlock system must be installed using STANLEY/BEST padlocks.
- 2.9.8. AOA Signs** -HAS will furnish sign graphics in the form of a master suitable for photographic enlargement. Signs must be constructed of screen-printed reflective vinyl film on a .080-inch anodized aluminum panel. Anchor signs to fence fabric with #6 galvanized wire ties.
- 2.9.9. Fence Signs** - Warning signs must be affixed to the fence on centers of 200 feet maximum and at each turn of the fence of 45 degrees or greater. Signs must be 24 inches in height by 30 inches in width. Fence sign graphics must include the Airport brand and the following copy: “Air Operations Area – No Trespassing” Sign specifications can be obtained from the HAS Sign Shop.
- 2.9.10. Gate Signs** – All AOA gates will be assigned a gate number by HAS Security. Sign specifications can be obtained from the HAS Sign Shop.
- 2.9.11. Concrete Mow Strip** – A concrete mow strip 36 inches in width centered on the fence must be installed at all permanent fencing. The concrete strip must be four (4) inches in thickness and reinforced with flat 6-inch by 6-inch, W2.9 X W2.9, welded wire fabric. Place on two-inch sand cushion. Provide contraction joints spaced four (4) feet on center and pre-molded one half (1/2) inch expansion joint material spaced at thirty-two (32) feet on center.
- 2.9.12. Post and Cable System** – A post and cable system must be installed in all areas where vehicles have unobstructed access to fences and gates adjacent to runways and taxiways. Acceptable systems are CASStm system by Trinity Industries, Inc., Brifen Wire Roper Safety Fence by Brifen USA or an approved equal.
- 2.9.13. Concrete Traffic Barriers** – Concrete traffic barriers (CTB) must be installed on the AOA side of AOA gates parallel to and three feet from the gate.
- 2.9.14. AOA Fence Screening and Equipment** – Screenings must not be attached to AOA fencing. A separation dimension of 10 feet must be maintained between the AOA fence and any movable objects such as equipment or any other object that may provide a platform.
- 2.9.15. AOA Gate Barriers** - At manned AOA gates, when barriers are required by the HAS Airport General Manager, provide a surface mounted barricade system equal to Delta Scientific Corporation (TW2015) or Natsatka Barrier, Inc. as follows:
- Hydraulic or pneumatic controlled barricade system with one-inch thick, eighteen-inch high metal plate in specified length to act as a physical barrier to entry or exit when in the raised position.
 - Provide surface-mounted, above grade installation.
 - The system must be crash rated based on US Corps of Engineers acceptance criteria of at least 5,000 pounds at 30 miles per hour.
 - The barricade must be automatically lowered to allow passage of authorized vehicles by card swipe through the Airport Board’s Automatic Access Control System (AACS), and the barricades must be capable of being operated by authorized personnel pushing a button inside the guard station. The barricade must have a minimum height in the up position of 21 inches, and when lowered must be less than 2” in height.

- 2.9.16. AOA Guard Stations** – Guard houses equal to Model DA75Sw as manufactured by Port-A-King Building Systems, Earth City, Mo may be required at manned AOA gates.

2.10. Turfing

- 2.10.1.** Sod must be used to establish turf on the AOA. The species of sod must be Bermuda, Coastal Bermuda, and/or Saint Augustine. Any exceptions must be coordinated with HAS Airside Operations and be approved by the Project Manager for the project.
- 2.10.2.** The placement of all turfing adjacent to paved shoulders and blast pavement must be 1-1/2 inches below the pavement surface to allow for proper drainage from the pavement edge. The finished grade of all earthwork will account for the thickness of sod panels such that the final finished elevation of the sod panel is appropriately recessed.
- 2.10.3.** All newly installed turf must be watered consistently every day for 20 minutes for the first 2 weeks and then every other day for 4 weeks. After week 4, watering must be done 3 times per week until the end of the 16th week. Rain events may reduce the frequency of watering required. Watering may be done by:
- Hand watering with a hose and attached sprinkler
 - Water truck or tanker
 - Temporary or permanent watering system using a battery-operated controller attached to a water source
- The watering plan will be reviewed by HAS Airside Operations and be approved by the Project Manager for the project.
- 2.10.4.** Wooden stakes or pegs are required to be installed in certain areas to prevent damage from jet blast or erosion on steep slopes.
- 2.10.5.** For all other turfing specifications see FAA AC 150/5370-10, *Standard Specifications for Construction of Airports*.
- 2.10.6.** All new turfing must be warrantied for at least one year.

2.11. Lighting Installation

- 2.11.1. Airfield Lighting:** Runway and taxiway lighting and visual aids must be designed based on the design standards and requirements of the FAA ACs, as appropriately supplemented by the National Electric Code (NEC) as it pertains to vault work and the commercial power side of the vault equipment. Any airfield component removed or replaced must be offered to HAS for first right of refusal. Any component to accepted by HAS must be disposed of by the contractor.
- 2.11.1.1. Lighting and Visual Aid Systems and Fixture:** System layout configuration and fixture utilization and design must be specified by all current applicable FAA ACs. Airport operated lighting systems must be designed for the most critical operational criteria per the Airport Layout Plan.
- 2.11.1.2. Lighting Specifications:** All specifications for lighting and electrical equipment, the item and manufacturer must be listed as approved for use by the FAA. In some instances, requirements above those required for FAA approval will be stipulated. These must be specified precisely; for example “Signs (L- 858) - To withstand high wind velocity up to 200 mph regardless of location.”
- 2.11.1.3.** Fixtures and lamps must be specified to match existing equipment whenever possible unless upgrade to Light Emitting Diode (LED) fixtures is approved by the Project Manager for the project. Fixtures must be installed on deep bases (cans) housing the isolation transformers. Inset (shallow) bases must not be used unless approved by the City Engineer. Runway Distance Remaining Signs and Taxiway Guidance Signs must be internally lighted to match

existing equipment. Any change in number of lights, or replacements of incandescent fixtures to LED may require upgrade of the regulators in the vault.

- 2.11.1.4. Cable and Conduit:** Direct burial cable is not permitted. All cables must be placed in conduit (polyvinyl chloride [PVC] Schedule 40 as minimum). Bends in underground conduit system are not permitted without a junction box. All cables must be tagged in manholes with heat sealing tags, Scotch HB-21 or approved equal, imprinted with the circuit number on each side of L823 connectors. 5 kilovolt (kV) series circuit cables must be color coded as to circuit type (e.g., Runway CKT, Taxiway CKT, Sign CKT). Verify color coding with HAS.
- 2.11.1.5. Electrical Manholes, Junction Boxes, and Pull Boxes:** These structures must be located outside runway and taxiway safety areas (as defined in FAA AC 150/5300-13) where HAS maintenance personnel can service them without closing runways or taxiways, if possible. They must sufficiently be raised, where allowed, above the surrounding grade to prevent ponding water on the structure. The top cover must be sloped to drain. A concrete apron must be constructed around all electrical manholes located in turfed areas. Particular attention must be given to storm-water drainage plans to prevent placement of electrical structures in areas of channeled for drainage. They must have all joints and openings completely sealed and vermin proof. Secure covers with bolts. Structures, covers and frames in the runway and taxiway safety areas must be heavy duty designed for aircraft at 250 psi tire pressures and wheel loads of at least 40,000 pounds. Homerun manholes and pull boxes must be located at a maximum spacing of 600 feet. If an existing non-rated box is used or impacted by the project, it must be upgraded to aircraft rated as well.
- 2.11.1.6. Saw Kerfs:** Saw kerfs are discouraged. However, where saw kerfs are required, only one 1-inch conduit per saw kerf is allowed.
- 2.11.2. Circuit Lockouts:** No construction or maintenance will be allowed on airfield lighting circuits while the circuits are energized. The HAS published circuit “Lock-out/Tag-out” procedures must be followed for all work performed on the airfield. The Contractor must follow HAS procedures then contact Airside Operations to coordinate access to electrical vault and for ATC Tower coordination/notifications. Airside Operations must be advised of temporary circuits requiring extended outages (more than one work period, 8 to 12 hours).
- 2.11.3. Airfield Lighting Control System:** Reconfiguration of the airfield lighting system, including will require update to the Airfield Lighting Control System (ALCS). Designer must provide provisions in the contract documents for the Contractor to coordinate with and pay ADB Safegate to update the graphics in the air traffic control tower (ATCT) and vault.

Part 3 – Execution

3.1. Airfield Technical Specifications

- 3.1.1. The Designer must coordinate with the HAS Project Manager to develop Airfield Technical Specifications on a project specific basis. Specifications must meet the current edition of FAA AC 150/5370-10, *Standard Specifications for Construction of Airports*. For TIP projects, portions of work that will support aircraft operations must also meet these specification requirements.
- 3.1.2. Any change or deviation from the standards in Design or Specification must be presented to the HAS Asset Engineering, Variance Review Committee for review and consideration, upon approval by the committee, it may be further submitted to the FAA for final consideration, based on the type and level of modification requirement.

Part 4 – Pavement Management

HAS Pavement Management/Maintenance Management Standard/Guide can be found at:
<https://www.fly2houston.com/biz/resources/building-standards-and-permits>

32- AIRCRAFT POTABLE WATER CABINET



32 - Aircraft Potable Water Cabinet

Part 1 – General

1.1. Overview

- 1.1.1.** The Consultant will specify aircraft potable water cabinet's (PWC) in agreement with the following. The aircraft PWC will be inclusive but not limited to the cabinet, hose reel, hose, aircraft connector, cartridge filter, and backflow preventer.

1.2. Quality Assurance

- 1.2.1.** The aircraft PWC manufacturer will follow current regulations developed by the Airline Drinking Water Rule (ADWR), the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the Federal Aviation Administration (FAA).

- 1.2.2. Manufacturer's Qualification:** Qualified firms must be regularly engaged in the manufacturing of potable water cabinets. The cabinets must be the type required, and the firm's product must have been used satisfactorily in a similar service for no less than three years.

1.2.3. Sequence and Schedule

- 1.2.3.1.** The Contractor will schedule rough-in installations with the installation of other building components. At a minimum the schedule must provide evidence of coordination between the passenger boarding bridges (PBB), pre-conditioned air units (PCA), ground power units (GPU), potable water treatment system (Houston Airport System [HAS] approved) and the water cabinet.

1.2.4. Maintenance Extra Stock:

- Furnish special wrenches and other devices necessary for servicing potable water cabinets to the Owner.
- The manufacturer will inform HAS and the PBB manufacturer in advance for structural, mechanical, electrical, communications, and safety provisions that need to be coordinated. Submit evidence of coordination with PBB manufacturer.

1.3. Shop Drawings and Submittals

- 1.3.1. Product Data:** Submit product data and installation instructions for potable water cabinets. All products and piping should be lead free and will comply with NSF61 or similar.

- 1.3.2. Shop Drawings:** Will include detailed dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages.

- 1.3.3. Wiring Diagrams:** Submit manufacturer's electrical requirements and wiring diagrams for power supply to the units. Clearly differentiate between portions of wiring that are factory installed and field installed.

- 1.3.4. Maintenance Data:** Include data in the Maintenance Manual.

1.3.5. Quality Control Submittals:

- 1.3.5.1. Submit certification of compliance agencies noted in 1.2.1. and as specified with Underwriters' Laboratories, Inc. (UL), FDA, and the American National Standards Institute (ANSI) Standards.
- 1.3.5.2. Submit certification of compliance with performance verification requirements specified in this Volume.
- 1.3.5.3. Water samples, test results, and reports.

1.4. Warranty

- 1.4.1. No specific requirements beyond the Manufacturer's one-year warranty.

Part 2 – Products

2.1. Manufacturers

- 2.1.1. Subject to compliance with specified requirements, provide potable water cabinets from the following manufacturers:
 - Phoenix Metal Products
 - Semler Industries
 - Or an approved equal

2.2. Cabinet Assembly

- 2.2.1. Provide a 25 gallon per minute (gpm) PWC consisting of a motorized hose reel, minimum 1-inch inner diameter (ID) water hose, valves, pressure regulator, pressure gauge, cabinet floor drain, aircraft coupling, low temperature warning signal, door left open warning signal, hose roller guide, automatic flush air gap, backflow preventer, and heated service cabinet.

2.3. Cabinet Components and Construction

- 2.3.1. Cabinet sidewalls, top, and bottom will be constructed using welded, double-wall, 304 stainless-steel or materials proven to withstand local ambient conditions, with 1-inch polystyrene insulation between minimum 16-gauge stainless steel sheets. Provide No. 4 polish finishes on the cabinet interior and exterior. Interior corners will be rounded to provide a cleanable surface and all sharp edges will be blunted. The cabinet roof will be pitched to force water runoff. Provide water runoff diversion drain, above the door, to keep rain water away from the door opening. Interior of cabinet bottom will be free of equipment, with no 90-degree corners, calking, welding, and kept free for drainage. All fasteners will be stainless steel.
- 2.3.2. Cabinet floor will have a 1-1/2-inch drain opening, and nominal pipe size (NPS) drain fitting, suitable for connection to the drain piping located below the cabinet. Bottom of cabinet will be pitched towards the drain opening.
- 2.3.3. Cabinet doors will have a two-point recessed locking handle with full length, stainless- steel piano

hinge and top-mounted door stops. Doors will be field replaceable, and the handles will be stainless-steel. Automotive grade weather stripping is required on doors.

2.3.4. Provide an engraved placard on the front exterior or on the doors stating, "POTABLE WATER".

2.3.5. The unit will have a 5-micron replaceable cartridge filter.

2.4. Stand

2.4.1. The cabinet will be mounted on a support stand as coordinated with the PBB manufacturer and HAS.

2.5. Electrical

2.5.1. All electrical components will be UL listed. All enclosures will be National Electrical Manufacturers Association (NEMA) 4X construction.

2.5.2. Junction Box with Terminal Strip: All wire connections are to be accomplished at a terminal strip that will be mounted in a junction box. All wires to be labeled to reflect the drawings and repair manual schematics.

2.5.3. Lighting: Provide 1,600 lumen LED light fixtures, weatherproof, and vapor proof with guard and internal watertight on-off switch, mounted inside the cabinet. Provide an amber colored rotating beacon light mounted on top of the cabinet, to be illuminated whenever the cabinet doors are open. Provide second contact for door switch for interlock control with the PBB.

2.5.4. Heaters: Provide heaters, sized as required, preventing contamination and freezing with a temperature limit switch. Provide an adjustable thermostat set at 50°F, with a positive on-off switch. Heated models will be designed to prevent shock hazards when the interior bottom is hosed down during daily cleaning. For worker safety, heated models will have no exposed heating elements. Domestic water pipes that are exposed to outside also need to be insulated and occupied with heat tracing for freeze protection.

2.5.5. Power Supply: Contractor will coordinate required power supply with electrical items. Provide any transformers required. All wiring will be provided in 3/4-inch or 1-inch threaded conduit, except flexible metal conduit to motor. Contractor will provide a three-pole 30A electrical disconnect switch in a NEMA 4X enclosure, mounted to the back of the potable water cabinet.

2.5.6. All wiring will be enclosed in flexible metal conduit or rigid galvanized conduit. Provide two 120-volt, one-phase circuits for each cabinet. Heaters to be on one 15-amp circuit and the motor light on one 15-amp circuit.

2.5.7. Convenience Outlet: Provide a convenience outlet inside the cabinet, 120 volts alternating current (VAC), 15-amp, ground-fault circuit interrupter (GFCI), feed through type, duplex with water resistant hinged cover.

2.6. Hose Reel

2.6.1. Hose reel will be Hannay Model EP-BA- 6028-25-26-RT or an approved equal with stainless-steel or brass internals, stainless-steel disk with aluminum drum, and stainless-steel frame.

2.6.2. Hose reel will be an electric rewind with ½-horsepower, reversible explosion-proof

2.6.3. motor with push button control and limit switch. Motor will operate on 120-volt, one- phase, and 60-hertz power supply. Provide a 650 rotations per minute (rpm) motor and 520 rpm gear reducer, explosion proof switch, solenoid, and junction box.

- 2.6.4.** Reel will have an auxiliary removable hand crank and adjustable tension/drag brake. Provide storage holder for hand crank.
- 2.6.5.** Rewind will be accomplished with a 2-inch palm button facing the cabinet front on right side. Palm button will be a mushroom type.
- 2.6.6.** Reel will have 1-inch low lead or stainless- steel swivel joint, brass, and low lead or stainless-steel internal piping.
- 2.6.7.** Provide a level four-way roller, fairlead, assembly to assist the operator in rewinding the hose without overlapping the disc with 6 inch diameter balls or discs.
- 2.6.8.** Hose reel will be back wall mounted in the cabinet to increase sanitary conditions, to limit rusting of bracketry and bolts used to mount the hose reel, and to facilitate cleaning of the cabinet bottom.

2.7. Hose

- 2.7.1.** Provide minimum 300 feet of 1-inch drinking water braided hose, FDA and National Sanitation Foundation (NSF) approved, K3150RF series Kuri-Tech or an approved equal. Provide brass ball valve with T- handle. The hose will be silicone free and resistant to ultra-violet (UV), algae, and bacteria growth.

2.8. Piping

- 2.8.1.** One-inch low lead or stainless-steel piping.
- 2.8.2.** Pressure regulator, adjustable 20 pounds per square (psi) to 125 psi outlet pressure with 2-1/2-inch diameter pressure gauge. Pressure regulator will be Cash ACME type EB-24U or an approved equal, with union inlet and built-in back pass check. Factory set to 75 psi, dead head pressure.
- 2.8.3.** Flexible 304 stainless-steel 1-inch hose reel connector, minimum 8 inches long.
- 2.8.4.** Hose nozzle, 1-inch stainless-steel construction, with dust cap and stainless- steel chain, suitable for quick coupling to aircraft connections, and drag cushion. The hoses will be protected with rubber bumpers to reduce impact damage.
- 2.8.5.** One-inch low lead or stainless-steel shutoff ball valve in the cabinet. One-inch ball valve at hose end nozzle.
- 2.8.6.** All plumbing piping insulated and occupied with heat tracing for freeze protection.

2.9. Biofilm Hazard Sensor

- 2.9.1.** To ensure consistent water quality, the unit will automatically flush the stagnant water to the drain and refill it with fresh water. The unit will be capable of draining stagnant water to the ramp area. Necessary non- clog drain outlets will be provided by the manufacturer. The drains will divert the water away from PBB or electrical equipment.

2.10. Water Cabinet Diagrams/ Schematics

- 2.10.1.** Provide a mechanical assembly diagram adhered to the interior right-hand door.
- 2.10.2.** Provide an electrical schematic adhered to the interior left-hand door.

Part 3 – Execution

3.1. Installation

3.1.1. Coordinate PWC installation with PBB manufacturer.

3.2. Testing

3.2.1. Examination

- 3.2.1.1. Verify all dimensions by field measurements. Verify that potable water cabinets may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- 3.2.1.2. Examine rough-in for potable water and waste piping to verify actual locations of piping connections prior to installing cabinets.
- 3.2.1.3. Do not proceed until unsatisfactory conditions have been corrected.

3.2.2. Field Quality Control

- 3.2.2.1. Test potable water cabinets to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, then retest and disinfect.
- 3.2.2.2. Inspect each installed unit for damage. Replace damaged components.
- 3.2.2.3. **Test water piping as follows:**
 - 3.2.2.3.1 Cap and subject piping to static water pressure of 50 pounds per square inch gauge (psig) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow standing for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3.2.2.3.2. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 3.2.2.3.3. Prepare reports for tests and required corrective action.

3.3. Cleaning

- 3.3.1. The units will be factory cleaned and disinfected prior to shipment. Units will be wrapped and shipped per FDA regulations. The Contractor will clean and disinfect potable-water piping prior to connection.
- 3.3.2. Clean cabinet interior and exterior and piping strainers.

3.4. Commissioning

- 3.4.1. The Contractor will fill water piping, check components to determine that they are not air bound, and that piping is full of water.
 - 3.4.1.1. Check equipment and verify proper settings, adjustments, and operation.
 - 3.4.1.2. Adjust water pressure at cabinets to provide proper flow and pressure to all aircraft parked at gate.

33- 400-HERTZ SOLID STATE FREQUENCY CONVERTERS



33 - 400-Hertz Solid State Frequency Converters

Part 1 – General

1.1. Scope

1.1.1. Design and plan for point-of-use 400 hertz ground power unit (GPU) and accessories at the following gates capable of servicing the required aircraft types:

1.1.1.1. Mount on new passenger boarding bridge(s) that will be installed to serve aircraft design groups III through VI.

1.1.1.2. All equipment and material will be new, undamaged, and meet the requirements of Underwriter's Laboratories, Inc. (UL) and Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 5015. Where UL requirements are not applicable, equipment and material will be identified as such by the Contractor and approved by Houston Airport System (HAS) before purchase and installation.

1.1.2. Delivery, Storage, and Handling

1.1.2.1. Store 400 hertz GPU so that it is protected from weather and so that condensation will not form on or in the units.

1.1.3. Project Conditions

1.1.3.1. Service Conditions: Institute of Electrical and Electronic Engineers (IEEE) C37.121, usual service conditions except for the following:

1.1.3.1.1. Exposure to hot and humid climates or to excessive moisture, including steam, salt spray, and dripping water.

1.1.4. Coordination

1.1.4.1. Coordinate with supplier of passenger loading bridge(s) for unit location and cable management.

1.2. Quality Assurance

1.2.1. Standards: Provide products complying with applicable parts of the latest edition of the following documents:

- SAE ARP - 5015
- National Electrical Code (NEC)
- IEEE Standards
- MIL-STD-704D Aircraft Electrical Power Characteristics
- MIL-STD 461B Electromagnetic Interference Characteristics Requirements for Equipment
- ARP-1148A
- ARP-1940

- American Society of Testing and Materials (ASTM) 123
- MIL-W-16878D Wire, Electrical, Insulated
- MIL-W-586A Wire, Electrical, Polyvinyl Chloride (PVC) Insulated, Copper or Alloy Copper
- MIL-I-8500 Interchangeability and Replace ability of Component Parts for Aircraft and Missiles
- International Electrotechnical Commission (IEC) National Electrical Manufacturers Association (NEMA) 6-78 Enclosures for Electrical Control Devices and Systems. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated.

1.2.2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in National Fire Protection Association (NFPA) 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2.3. Comply with IEEE C2

1.2.4. Comply with American National Standards Institute (ANSI) C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.

1.2.5. Comply with NFPA 70.

1.2.6. Turn-Key Operation: The Passenger Boarding Bridges will be designed, manufactured, installed, tested, delivered and supported as a fully integrated unit, in compliance with the requirements defined in the project specification, Contract Drawings, addenda and attachments. The Passenger Boarding Bridges will incorporate the HAS Standards for Passenger GPU, Pre-Conditioned Air, and Potable Water and be installed as a “Turn-Key” assembly at the designated gate.

1.3. Shop Drawings and Submittals

1.3.1. Submittals will include, but are not limited to, the following:

1.3.1.1. Unit cut sheets clearly showing all features, accessories, dimensions, weights, input requirements, and capacities.

1.3.1.2. Drawings showing the proposed location of the GPU and related accessories on the Passenger Boarding Bridges (PBB).

1.3.1.3. Shop drawing submittals will include, but are not limited to, the following:

1.3.1.3.1. Unit cut sheets clearly showing all features, accessories, dimensions, weights, and capacities.

1.3.1.3.2. Wiring and control diagrams. Power connection locations will be as specified.

1.3.1.3.3. Performance certifications and test results for the complete assembled units. Test results from typical units with the same design as the units being furnished, will be acceptable.

1.3.1.3.4. Written instructions will be provided for equipment installation and operation for HAS future reference.

1.3.1.3.5. Recommend spare parts list.

1.3.1.3.6. Warranty information.

1.3.1.4. Qualification data for the testing agency.

1.3.1.5. Source quality-control test reports.

1.3.1.6. Field quality-control test reports.

1.3.1.7. Follow-up service reports.

1.3.1.8. Operation and maintenance data.

Part 2 – Products

2.1. Manufacturers

2.1.1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:

- FCX Systems
- Hobart Ground Power
- JBT Aero Tech

2.2. Description

2.2.1. Provide 12-pulse frequency converters consisting of modular construction solid-state components for 60 to 400 hertz conversion, input/output devices, and ancillary control devices. Frequency converters will be a standard product of the manufacturer and will be the manufacturer's latest design that complies with the specification requirements. The 400 hertz frequency converters provided will be products of the same manufacturer. The converter will be UL or a third party listed to comply with UL 1012. Circuit breakers operating at 400 hertz will be designed and UL tested for 60 hertz operation and de-rated for 400 hertz operation. The converter will use circuitry limiting Total Harmonic Distortion (THD) to a maximum of 10 percent. Provide startup and shutdown instructions posted on the front of the unit using engraved plastic plate. Provide a plastic encapsulated schematic diagram attached to the inside of the unit in clear view of maintenance personnel.

2.2.2. Electrical Characteristics:

2.2.2.1. Input Power Factor: Between 0.8 lagging and unity, under all conditions of steady state line and load variations specified herein.

2.2.2.2. Surge Protection: The converter will be capable of sustaining an input surge described within and tested in accordance with UL 1449, location Category B, and continue to operate with no alarms within the specified tolerance.

2.2.2.3. Input Current Distortion: THD will not exceed 6 percent of the fundamental with nominal input voltage.

2.2.2.4. Output: Each ground power unit will be capable of 400 hertz, three-phase 115/200 volts alternating current (VAC) output.

2.2.2.5. 400 hertz Output: power output at 0.8 power factor lagging 115/200 VAC, three phase, 400 hertz grounded system. The limits over voltage and under voltage will be as defined in MIL-STD-704. The phase rotation of the output will be clockwise sequence of A-B-C.

2.2.2.6. Efficiency: The units will have a minimum efficiency of 90 percent and between a 50 percent to 100 percent load.

2.2.2.7. No Load Input Losses: The frequency converter will have no-load input losses no greater than 5 percent of the output kVA rating.

2.2.2.8. Overload/Overcurrent: Satisfactory overload/overcurrent operating time is based on no more than one overload in any four consecutive hours of operation:

Exhibit 14-1: Overload and Overcurrent Table

Percent of Full Load	Satisfactory Operating time
115 percent	60 Minutes
125 percent	10 Minutes
150 percent	30 Seconds
200 percent	10 Seconds
250 percent	.5 Seconds

2.2.2.9. **Short Circuit:** When a bolted line-to-ground fault, a bolted line-to-line fault, or a bolted three-phase fault is applied to the unit, the unit will be capable of sustaining the short circuit current without damage until the protective device interrupts the fault.

2.2.2.10. **Output THD:**

2.2.2.11. **Balanced load:**

2.2.2.12. **THD:** Not to exceed 3 percent line-to-line and line-to-neutral.

2.2.2.13. **Maximum Single Harmonic Distortion:** Not to exceed 2 percent of the fundamental at the nominal voltage.

2.2.2.14. **Unbalanced Load:** THD not to exceed 4 percent, line-to-neutral with 15 percent unbalanced load.

2.2.2.15. **Amplitude Modulation:** Will not exceed ½ percent no load to full load.

2.2.2.16. **Frequency Stability:** Provide a high frequency crystal clock to control output frequency of the 400 hertz converter within plus or minus 0.5 percent for all operating conditions, including maximum and minimum specified input voltages, ambient temperature, and relative humidity. The frequency regulation will operate independent of supply frequency and load changes.

2.2.2.17. **Phase Angle Regulation:** Displacement angle between adjacent voltage phases will be 2.09 rad (120 degrees), plus or minus 0.0349 rad (2 degrees), with balanced load and plus or minus 0.0698 rad (4 degrees) with three-phase 15 percent unbalanced load. A 15 percent unbalanced load is defined as:

2.2.2.17.1. Phase A at full rated single load.

2.2.2.17.2. Phase B at 85 percent of Phase A.

2.2.2.17.3. Phase C at 85 percent of Phase A.

2.2.2.18. **Transient Output Voltage Recovery:** In accordance with MIL-STD-704.

2.2.2.19. **Electromagnetic Interference:** The frequency converter will meet radiated and conductor limits of radio suppression specification MIL-STD-461. It will be capable of operating through the entire aircraft and land mobile radio frequency range without production interference.

2.2.2.20. **Environmental Rating:**

2.2.2.20.1. The converter will operate satisfactorily from no load, to rated full load under the following conditions:

2.2.2.20.2. Ambient temperatures ranging from -25.6°F to 122°F.

2.2.2.20.3. Relative humidity from 10 to 95 percent noncondensing.

2.2.2.20.4. Ambient pressures from sea level to 3,000 feet, without derating.

2.2.2.20.5. Wind up to 80 miles per hour (MPH) steady with gusts up to 125 MPH.

2.2.2.21. **Monitoring and Control Panel:**

2.2.2.22. Provide a converter with a control panel that is equipped with the following controls, indicators, instrumentation, data logging, diagnostics, and alarm functions.

2.2.2.22.1. **Controls:**

- Start/stop pushbuttons.
- Lamp/light emitting diode (LED) test:
- A push-to-test button, or switch, to test indicator lamps/LEDs if control panel is equipped with LEDs.
- Output Voltage Adjust: Locate output voltage control inside converter enclosure, available for adjustment by maintenance personnel only when the door is open.
- The unit must have capability to communicate with Gate Management System with seamless integration.

2.2.2.22.2. **Indicators:** Provide the following indicators either by LED or digital display:

- Input power available
- Output power on/off
- System alarm
- Aircraft interlock bypass

2.2.2.22.3. **Instrumentation:**

- Elapsed time (in hours)
- Output voltmeter capable of monitoring all three phases and providing an average.
- Output ammeter capable of monitoring all phase currents and providing an average.

2.2.2.22.4. **Alarms:** The unit will be capable of detecting the following abnormal conditions and displaying an alarm indication for the following:

- Input over voltage
- Input under voltage
- Output under voltage
- Output over voltage
- Output overload
- System alarm
- Control logic failure
- Frequency deviation
- Over temperature
- Logic power supply failure

2.2.2.23. **Input/Output Devices:** Provide fully- rated, three-pole, UL approved devices for control of 60 hertz input and 400 hertz output from the converter. Devices and cables operating at 400 hertz will be de- rated in accordance with IEEE Standard 519.

2.2.2.23.1. **Circuit Breaker:** Conform to requirements of UL 489. Units operating at 400 hertz will be de- rated for 400 hertz operation.

2.2.2.23.2. **Input Circuit Breaker:** Provide converter with a UL listed input circuit breaker as an integral part of the converter.

2.2.2.23.3. **Output Contactor:** Provide converter output with an automatic, magnetically- held, contactor with interlock circuit. Output contactor will be of sufficient capacity to handle rated load, overload, and available short circuit current. Contactor will be tripped by any circuit

identified in the paragraph entitled Protective Control. Output contactor will be electrically interlocked with On/ Off circuitry so that when the frequency converter is shut down, the contactor will open immediately and remain open. Conform to the requirements of IEC 158-1.

- 2.2.2.23.4. **Aircraft Interlock Circuit:** Interlock circuit will determine the presence or absence of the 28 volts of direct current (VDC) feedback signal from the aircraft. Interlock circuit will not allow the output disconnect to close if the 28 VDC signal is not present. If the output disconnect is closed when the 28 VDC is lost, disconnect will open within 2 seconds. Converter will contain terminal block points for the connection of two 12 American Wire Gauge (AWG) wire from the aircraft cable assembly for the interlock circuit. Interlock circuit will not draw more than 20 milliamperes from the aircraft's 28 VDC circuit. For testing purposes, provide a switch inside the converter with two positions:
- **Normal:** For aircraft loads
 - **Bypass:** For testing with dummy load, no load, or for use with aircraft with no 28 VDC.
- 2.2.2.23.5. **Horizontal Drive Interlock:** The PBB horizontal drive operation will be locked out whenever the GPU is operating, the alarm and flashing will operate on console. The PBB operator's console will be equipped with GPU flashing warning light and audible alarm.
- 2.2.2.23.6. **400 hertz Output:**
- The unit will have an eight-place terminal block, factory installed and labeled, for the connection of each 400 hertz output cable head with the unit start/stop buttons and the cable hoist up/down buttons. The terminal block will have each block labeled to identify each of the connections.
 - The PBB will be equipped with 400 hertz cable hoists, with a placard saying 400 Hertz Unit, push-button control switch station equipped with hoist up/down pushbutton switches, unit start/stop buttons, and 28-volt indication LED.
 - Each unit will be equipped with two, Mil Spec approved, 400 hertz output cables manufactured by J and B Aviation. Each cable will have a single, heavy-duty, neoprene jacket, eliminating the need for banding, and will have a plug with replaceable Thermgard nose section. The power cables will be equipped with hoist up/down and unit start/stop buttons in the head. Provide two 100-foot cables for unit. Provide minimum of four saddles for each cable suspended from cable hoist.
- 2.2.2.23.7. **Cable Hoist:** Provide dual cable hoist for each 400-hertz unit to support the two 400 hertz cables associated with each unit. Hoist will be located on the roof of the PBB cab. Hoist will be equipped with a warning light and alarm circuit which will be engaged on the console when the cable hoist is lowered. The cable hoist input power will be protected by circuit breakers, not fuses. The circuit breakers are to be located inside of the PBB operator's console and must be clearly labeled and identified with a placard. Cable hoist will have enough saddles to accommodate cable lengths stated above.
- 2.2.2.23.8. **Protective Controls: Provide circuitry for the following protective controls.**
- 2.2.2.23.9. Input under voltage
- 2.2.2.23.10. Input over voltage
- 2.2.2.23.11. Loss of phase
- 2.2.2.23.12. Loss of input power
- 2.2.2.23.13. **Door interlock:** When any access door is opened, the interlock circuitry will open the 60 hertz input device and not allow the input device to close. For maintenance purposes, provide

a bypass switch to defeat the interlock circuitry.

- 2.2.2.23.14. **Output Over Voltage:** Comply with MIL- STD-704E.
- 2.2.2.23.15. **Output Under Voltage:** Comply with MIL-STD-704E.
- 2.2.2.23.16. **Output Frequency:** Protect by tripping output devices for frequency change more than plus or minus 5 percent of the rated output frequency (400 hertz).
- 2.2.2.23.17. Output Overload.
- 2.2.2.23.18. Converter Over Temperature Protection: Provide a thermistor to detect silicon-controlled rectifier (SCR) mounting surface and activate automatic shutdown if the temperature exceeds 177°F.
- 2.2.2.24. **Automatic Line Drop Compensation:** Provide automatic line drop compensation - 0 to 7 percent adjustable internally.
- 2.2.2.25. **Built-In Test Equipment:** Frequency converter will include built-in test equipment which monitors both primary circuits and protection circuits of the unit. Provide visual indication to assist diagnosis of unit failures to a modular level. Provide visual indication of converter status using cabinet mounted LEDs.
- 2.2.2.26. **Magnetic Devices:** Provide Class 180 power magnetic transformer and inductors in accordance with NEMA ST 20 and UL 506. The limits of Class 180 will not be exceeded at the maximum specified ambient temperature and at 100 percent load.
- 2.2.2.27. **Acoustical Noise:** A maximum continuous acoustical noise level of 70 A-scale decibels (dBA), a weighted scale.
- 2.2.2.28. **Assembly Construction:** Provide enclosures suitable for outdoor environments in accordance with NEMA 250, Type 3R. Arrange to provide required louvers, cooling air, entry, and exit provisions for equipment within enclosures. Construct unit(s) so that components, with the exception of control and monitoring components, are totally enclosed within the enclosure. Electronic circuits, including power circuits, will be modular construction readily accessible for maintenance, repair, and module replacement from the exterior of the enclosure. Provide permanent identification tags and uniquely identify each wire. Use the same identification system in the wiring diagrams in the Operation and Maintenance Manual. Provide each enclosure with a finish coat over a substrate which has been provided with a rust inhibiting treatment. Provide two finish coats for outdoor enclosures. Color will be the manufacturer's standard color.
- 2.2.2.29. **Nameplates:** Provide nameplate on each 400 hertz unit indicating manufacturer, model number, kVA rating, and other applicable data.
- 2.2.2.30. A circuit will be included in the frequency converter to allow for operation during the transfer of power from aircraft to external power for aircraft that have this no break power transfer (NBPT) feature.

2.2.3. Source Quality Control

- 2.2.3.1. **Routine Factory Tests:** Test every converter to assure compliance with the specifications as follows:
 - 2.2.3.1.1. **Load Bank Test:** Test for one hour at 50 percent kilowatt (kW) and one hour at approximately 100 percent kW capacity. Monitor voltage, frequency, and current at 15-minute intervals during testing.
 - 2.2.3.1.2. **Efficiency Test:** Test efficiency for 25, 50, 75, 90 and 100 percent loading.
 - 2.2.3.1.3. **Burn-in Test:** Before delivery, operate each converter for a minimum of 16 hours.
- 2.2.3.2. **Special Factory Test:** Test 180 kVA converter to assure compliance with the specifications as follows:

- 2.2.3.2.1. **Harmonic Distortion:** Provide test results of input harmonic currents and voltages. The test data will include total harmonic distortion and amplitudes of individual harmonics in graphic representation for no load, 25, 50, 75 and 100 percent load factors.
- 2.2.3.2.2. **No Load Losses:** Operate at no load and nominal input voltage. Measure and record input voltage, output voltage, and output frequency.
- 2.2.3.2.3. Voltage balance (output)
- 2.2.3.2.4. Voltage balance (input)
- 2.2.3.2.5. Transient voltage dip and response at 0.9 power factor (pf) (output).
- 2.2.3.2.6. Frequency regulation (output)
- 2.2.3.2.7. Overload
- 2.2.3.2.8. Each safety operating device
- 2.2.3.2.9. Line drop compensation circuit
- 2.2.3.2.10. Input current harmonics

Part 3 – Execution

3.1. Installation

- 3.1.1.** Conform to the requirements of NFPA 70, IEEE C2, and to manufacturer's instructions and recommendations. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Install systems, materials, and equipment to conform with approved submittal data to greatest extent possible. Conform to arrangements indicated by the contract documents. Should coordination requirements conflict with individual system requirements, refer conflict to the HAS Project Representative in writing
- 3.1.2.** As much as practical, connect equipment for ease of disconnecting with minimum interference with other equipment of different horsepower, kW, or kVA size than that shown on the contract documents and furnished by the Contractor. Contractor will furnish and install the proper support equipment, motor starter, switchgear, feeders, fuses, circuit breaker, disconnect switch, wire, and conduit required for the equipment at no additional cost to HAS.
 - 3.1.2.1. Equipment:**
 - 3.1.2.1.1. Provide proper mounting channels to install on underside of passenger boarding bridge. Install in accordance with the manufacturer's drawings and instructions as indicated. Align, level, and bolt/weld units to channels to allow easy withdrawal or insertion of removable components. This also helps to permit proper orientation and maintenance of equipment.
 - 3.1.2.2. **Grounding:** In accordance with NFPA 70.
 - 3.1.2.3. **Wiring and Conduit:** Provide Mil Spec approved 400 hertz aircraft cabling for 400 hertz output.
 - 3.1.2.4. **Manufacturer's Representative:** The manufacturer's representative will place the system in operation and make necessary adjustments to ensure optimum operation of the equipment. The manufacturer's representative will have at least two years of practical experience in the installation and testing of 400 hertz solid state frequency converters.
 - 3.1.3.** Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2. Testing

3.2.1. Examination

3.2.1.1. Examine areas and conditions for compliance with requirements for 400 hertz GPUs.

3.2.1.2. Examine roughing-in of conduits and grounding systems to verify the following:

3.2.1.2.1. Wiring entries comply with layout requirements.

3.2.1.3. Entries are within conduit-entry, tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

3.2.1.4. Examine walls, floors, roofs, and passenger loading bridges for suitable mounting conditions where 400 hertz GPUs will be installed.

3.2.1.5. Verify that ground connections are in place and that requirements for grounding and bonding of electrical systems have been met. Maximum ground resistance will be 5 ohms at location of 400 hertz GPU.

3.2.1.6. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2.2. Quality Assurance

3.2.2.1. The following describes the minimum inspection and testing required in the Contractor's Quality Control Program. The implementation of a Contractor Quality Control Program does not relieve the Contractor from the responsibility to provide work in accordance with the contract documents, applicable codes, regulations, and Governing Authorities.

3.2.2.2. The Contractor Quality Control Program will include, but not be limited to, the elements included herein. These elements are provided only as a minimum starting point for the Contractor to use to generate the complete Contractor's Quality Control Program.

3.2.3. Field Quality Control

3.2.3.1. **Performance of Acceptance Checks and Tests:** Perform field tests and conduct inspections on each unit after installation on PBB. Provide labor, equipment tests instruments, and incidentals required for the tests, including load banks.

3.2.3.2. **Instruments:** The test plan will list make and model, and provide functional description of the test instruments, accessories, and will describe the setup

of the tests to be conducted. Provide test instruments capable of measuring and recording, or displaying, test data at a higher resolution and greater accuracy than specified for the converter's performance. The test instruments used in the field tests will have current and valid calibration stickers issued by an approved calibration laboratory. Verify calibration and adjustments of converter instruments provided prior to field tests. Instruments will be calibrated for 400 hertz operation when measuring 400 hertz signals.

3.2.3.3. **Performance Tests:** Conduct converter performance tests under the supervision of the manufacturer's representative on each unit. Successfully complete the preliminary operation, control, and protective

devices check prior to performing load and transient tests. If the converter fails to operate within the specified limits during any of the performance tests, the Contractor will discontinue the test and will make necessary repairs to correct the failure and retest the converter.

3.2.3.3.1. Inspect the converter and make adjustments necessary to assure proper operation in accordance with the manufacturer's instructions. Contractor will demonstrate the following shut down features on all units:

- Removal of the plug connector from aircraft receptacle
- Sustained load exceeding 115 percent of rated power

- Over or under voltage
 - Loss of phase or phase rotation reversal.
 - Loss of input power
 - Loss or interruption of 28 VDC monitoring voltage
- 3.2.3.3.2. The Contractor will demonstrate the interlocking operation of the system.
- 3.2.3.3.3. **Control and Protective Device Checks:** Operate each control, switch, input/output device that is capable of being operated manually a minimum of three times, and demonstrate satisfactory operation each time. Perform operation test on each protective device to ensure that devices function properly. After each operation, measure and record the converter output frequency, voltage, and current. Verify converter is operating within specified limits.
- 3.2.3.3.4. **Load Test:** Continuously operate each unit a minimum of one hour at 100 percent kW load and one hour at 50 percent kW load. Test will be at 1.0 pf and will utilize resistive load banks. During the operation, measure and record the converter output frequency, voltage, and current at 15 minute intervals. Verify converter is operating within specified limits.

3.3. Training

- 3.3.1.** Provide field training to personnel on the operation and maintenance of the converter provided. As a minimum, the training will include two hours of instruction on the theory of operation and four hours on the repair and maintenance of the converters. The instructor will be approved by the manufacturer of the unit provided.
- 3.3.2.** Training must be approved by HAS at least two weeks in advance. Provide two copies of the training sessions on media as requested by the HAS Project Manager to HAS upon completion.

34- PASSENGER BOARDING BRIDGES



34 - Passenger Boarding Bridges

Part 1 – General

1.1. Introduction

- 1.1.1. Passenger Boarding Bridges (PBB):** Designer will specify new apron drive PBB and fixed walkways to match the aircraft types planned for the gates as shown on the drawings and as described within this Standard. The PBBs must include all structural, support, mechanical, electrical, and finish requirements to serve Airplane Design Groups (ADG) III, IV, V, and VI as required by the aircraft mix.
- 1.1.2. Fixed Walkways:** Provide new fixed walkway sections as indicated on the drawings and in this section. The fixed walkway tunnel extension will meet all structural and finish requirements specified for the PBBs.
- 1.1.3. Design:** The PBBs will be of telescoping three-tunnel design. The passenger boarding bridges will match the aircraft types planned for the gates.

1.2. Operations

- 1.2.1. Operation Limits:** The apron drive bridges can move to any point on the terminal apron within the design operation range to accommodate the indicated aircraft. The apron drive bridges will have simultaneous directional movements including extension, retraction, lateral motion, vertical elevation, and cab rotation. Each PBB will have a minimum continuous operation range as indicated on the drawings. The PBBs will be measured from the center point of the rotunda to the center point of cab rotation. The passenger boarding bridges will meet the full continuous range of horizontal and vertical movement, specified throughout the full continuous range of cab rotation, without requiring field modification to meet the full range of movement.
- 1.2.2. Operating Environment:** Design temperatures for the summer and winter are:
- Summer: Dry Bulb Temperature: 98°F
 - Summer: Wet Bulb Temperature: 80°F
 - Summer: Maximum Temperature: 120°F
 - Winter: Dry Bulb Temperature: 20°F
- 1.2.2.1.** The entire bridge will be weatherproof while extended at a parked aircraft and in the stowed position with the cab door closed. Equipment and controls exposed to the weather will be weatherproof-type or housed in weatherproof enclosures. Electrical panels or cabinets mounted externally to the bridge will be equipped with heaters or electric components to control condensation where required by the installation environment.

1.3. Safety Requirements

- 1.3.1.** The purpose of this Standard is to describe the requirements, quantities, performance, and maintenance properties of the boarding bridge design and installation. Safety to passengers, employees, other personnel, aircraft, and equipment is of prime importance. Nothing in the specifications will relieve the manufacturer or Contractor of the responsibility for providing, and installing, a safe product.

- 1.3.1.1. All equipment will be designed to be fail- safe, and all controls that regulate bridge motions like horizontal travel, vertical travel, and cab rotation will be of the dead- man type. Dead-man type is defined as controls that require the operator to apply constant pressure to be engaged. Once the pressure is released the control is disengaged.
- 1.3.1.2. All operating mechanisms like horizontal drive, vertical drive, and cab rotation will be designed so the drive mechanism is locked when power fails or is shut off.
- 1.3.1.3. Positive mechanical stops will be provided to prevent over-travel where any component might become disengaged from its guiding or restraining component. The positive stop must be in addition to all limit switches provided to restrict over- travel during normal operating conditions, including drive wheel steering motions, and cab rotation. This does not apply to tunnel rotation which will have dual limit switches. Mechanical stops will be identified and detailed on the shop drawings.
- 1.3.1.4. The operator's position in the control cab will be designed to provide adequate visibility to position the boarding bridge with the cab weather door closed. Suitable enclosures, guard rails, and other restraint devices will be provided to protect the operator from being pitched out the open end of the cab in case of sudden stops or inadvertent movements of the bridge when operated with the door open. A handhold will be attached to the wall on one side of the cab weather door.
- 1.3.1.5. Fall protection will be provided for technicians working on the roof consisting of a stainless-steel tie-off cable and safety- caged roof access ladder.
- 1.3.1.6. Highly reflective and daylight visible safety stripes will be provided on any equipment mounted below the boarding bridge.
- 1.3.1.7. Safety decals will be provided on the cross tube of the drive column bogie wheel to warn about bridge motion and operator safety.
- 1.3.1.8. PBBs will meet the full continuous range of vertical travel to service all aircraft indicated on the drawings. They are measured from the apron to the cab spacer leveled edge with the cab fully rotated counterclockwise, as installed, without requiring field modification.

1.4. Qualifications

- 1.4.1. The manufacturer and installer will provide evidence of at least 5 years of satisfactory experience in the design, fabrication, and installation of tunnel apron drive PBBs. The installer will be trained and certified by the manufacturer as having the necessary experience, staff, and training to install the manufacturer's products per the specified requirements. Materials used will have been used successfully in similar installations and must have withstood exposure for a period of at least 5 years.
- 1.4.2. **Factory Inspection:** HAS Representatives reserve the right to perform preliminary inspections of the equipment at the factory before delivery. Coordinate dates and times of factory inspection with the HAS Project Representative.
- 1.4.3. **Turn-Key Operations:** The PBBs will be designed, manufactured, installed, tested, delivered and supported as a fully integrated unit, in compliance with the requirements defined in the Project Specification, Contract Drawings, addenda and attachments. The PBBs will incorporate the HAS Standards for Passenger Pre-Conditioned Air, Ground Power Unit, Potable Water and be installed by the contractor at the designated gate.

1.5. Shop Drawings and Submittals

- 1.5.1. An index prepared in sequential order listing all drawings, sketches, details, and material submitted.
- 1.5.2. Project-specific general arrangement drawings.
- 1.5.3. **Product Data:** Manufacturer's technical product data, including specifications. Include data substantiating that materials comply with requirements.

1.5.4. Interior Finishes:

- 1.5.4.1. Interior finish schedule including interior walls and ceiling finishes. Include physical characteristics such as durability, resistance to fading, flame resistance, and manufacturer's recommendations for maximum permissible moisture content of substrates.
- 1.5.4.2. Wall material impact resistance test report, when applicable
- 1.5.4.3. Transition details
- 1.5.4.4. Wall finish attachment methods, when applicable
- 1.5.4.5. Light fixture details, ceiling materials, layout, and maintained illumination calculations at floor using the actual interior finishes.
- 1.5.4.6. 10 percent reflectance for the floor surface
- 1.5.4.7. Boarding bridge, fixed walkway section dimensions, and general arrangement drawings
- 1.5.4.8. Tunnel floor finish
- 1.5.4.9. Cab floor finish
- 1.5.4.10. Floor covering edging details, including lines of demarcation between covered and hard surfaced floor at wall areas, and treatment at doors and thresholds
- 1.5.4.11. Floor covering quantity
- 1.5.4.12. Insulation
- 1.5.4.13. Handrail details
- 1.5.4.14. Bridge precooling/preheating grille
- 1.5.4.15. Approval by the HAS Security Manager, for locations of the Security camera, is required

1.5.5. Exterior Configuration:

- 1.5.5.1. General bridge and walkway layout
- 1.5.5.2. Exterior elevations
- 1.5.5.3. Graphics/signage details
- 1.5.5.4. Paint finishes
- 1.5.5.5. **Flashing:**
 - 1.5.5.5.1. Building to fixed walkway
 - 1.5.5.5.2. Fixed walkway section to passenger boarding bridge
 - 1.5.5.5.3. Bridge segments
- 1.5.5.6. Cab door seal
 - 1.5.5.7. PBB roof service/maintenance ladder, cage and cab roof handrails, roof fall protection cables, and connection points
 - 1.5.5.8. Lighted gate sign
 - 1.5.5.9. Pre-conditioned air (PCA) unit, 400 hertz unit, potable water cabinet (PWC), and PBB interface and mounting details

1.5.6. Cab:

- 1.5.6.1. Operator's cone of visibility, including mirrors for viewing drive wheels and apron
- 1.5.6.2. Control panel location and functional layout
- 1.5.6.3. View panels
- 1.5.6.4. Safety devices, including proximity sensor product data
- 1.5.6.5. Canopy closure fuselage seal interface detail for A380 aircraft service
- 1.5.6.6. Modifications necessary for proper connection with required aircraft types including auto-leveling

devices

1.5.6.7. Operating instructions placard

1.5.6.8. Cab doors

1.5.7. Aesthetics and Safety Markings:

1.5.7.1. Color and finish, exterior

1.5.7.2. Reflective safety stripes on all equipment mounted below PBB

1.5.7.3. Signage and plaques; interior and exterior during normal and emergency conditions

1.5.8. Accessories:

1.5.8.1. Fixed walkway cooling unit

1.5.8.2. Ventilator unit

1.5.9. Electrical, Mechanical, Structural:

1.5.9.1. Certifications of compliance with all applicable Design and Construction Standards

1.5.9.2. Electrical drawings, including all pertinent power calculations, will be signed and sealed by a professional engineer legally authorized to practice in the State of Texas.

1.5.9.3. Electrical power and control schematic diagrams

1.5.9.4. Hydraulic schematics

1.5.9.5. Interface requirements for foundations and building supplied utilities. Provide exact location of electrical power and communications junction boxes.

1.5.9.6. Structural drawings, including all pertinent calculations, will be signed and sealed by a professional engineer legally authorized to practice in the State of Texas.

1.5.9.7. Welder qualifications and weld procedure qualifications

1.5.9.8. The manufacturer will provide the HAS Project Representative with actual foundation attachment configuration and loading data sheets for each type of bridge provided based on load requirements defined in the Structural Design and Support Elements Article in Part 2 of this Standard. Foundation loads will include design forces and moments, in three directions, at the column base due to dead, live, wind, and seismic loads. In addition, furnish bolting layout with dimensions.

1.5.10. Anti-Collision System:

1.5.10.1. Proximity sensors product data

1.5.10.2. Laser collision avoidance product data

1.5.10.3. Anti-collision system installation schematics showing sensor and laser locations for new and existing PBB

1.5.10.4. Collision avoidance system program description and program, including ladder logic for the new PBB and existing PBB

1.5.10.5. All associated controls

1.5.11. Certificates of compliance with National Fire Protection Association (NFPA) 415 from a certified testing company located in the continental United States. The manufacturer will also provide affidavits attesting to the PBB's compliance with NFPA 415, including the following:

1.5.11.1. Provide fire test results, per NFPA 415 Chapter 6, for actual materials provided in the PBB, including walls and floors, flexible closures, cab and rotunda curtain slats, aircraft bumper, and miscellaneous seals and weather stripping.

1.5.11.2. Provide evidence of compliance with NFPA 415 Chapter 6, design requirements.

1.5.11.3. Provide evidence of compliance with NFPA 415 Chapter 6, materials requirements.

1.5.12. Furnish notarized certifications that the bridge and fixed walkway, including all electrical, mechanical

and hydraulic designs, components, and installations meet the requirements prescribed in this Standard.

- 1.5.13.** List of recommended spare parts for a duration of at least two years of operation, including prices and sources.
- 1.5.14.** Submit detailed procedures for Functional Site Testing methods for approval, prior to start-up and testing of the bridge.

1.6. Warranty

- 1.6.1. Special Project Warranty:** Provide special project warranty, signed by Contractor, installer, and manufacturer, agreeing to replace, repair, or restore defective materials and workmanship of PBB and fixed walkway work during warranty period of 2 years from final acceptance. Manufacturer will also provide a 5-year warranty to replace defective motors and inverters; motors and gearboxes; horizontal drive motors; gearboxes and control systems; wheel bogie assembly; lift column assemblies; control systems; hydraulic power units; roller assemblies' tunnel frame work and sheet metal in its entirety; cab assembly, rotating and side shifting drive components, bearings and sheet metal enclosures' rotunda assembly and sheet metal enclosures; cab and rotunda curtain assemblies to include motors, shafts, bearings, bushings, guides and control systems; canopy assembly and control system; articulating floor assembly and control system; auto level components and control system; all electrical tap blocks, and components related to the electrical operating systems; and all programmable logic controller (PLC)/computer systems for the bridge. This warranty will be in addition to, and not a limitation of, other rights that HAS may have against the Contractor under the Contract Documents.
 - 1.6.1.1.** Defective is defined to include, but not limited to, operation or control system failures, performances below required minimums, excessive wear, unusual deterioration or aging of materials or finishes, unsafe conditions, the need for excessive maintenance, abnormal noise or vibration, similar unusual, unexpected, and unsatisfactory conditions.
 - 1.6.1.2. Warranty Claim Response Time:** The manufacturer will ship repair parts and send a qualified service technician, if required, to HAS within 24 hours of being notified of an equipment failure while under warranty. Parts will be delivered to the facility within 48 hours from the time the order was placed. If the manufacturer is unable to obtain the parts to restore the equipment to service, HAS reserves the right to obtain the replacement parts or service elsewhere and invoice the total cost to the manufacturer, including labor and administrative fees. The manufacturer will pay all customs fees, taxes, and freight for warranty parts during the warranty period.

Part 2 – Products

2.1. Manufacturers

- 2.1.1.** Confirm manufacturers acceptable to HAS with the HAS Project Representative.
- 2.1.2.** Where components are not otherwise indicated, provide standard components published by the manufacturer as included in standard pre-engineered PBB, fixed walkway systems, and as required for a complete system. All equipment and parts furnished will be the manufacturer's latest listed and published stock models, except as permitted or required by the HAS Project Representative. The equipment and parts will meet all the applicable requirements of the specifications.

2.2. Electrical Components

- 2.2.1. Operational control limit switches will be of the proximity type where practical. Ultimate travel limit switches will be of the mechanical type.
- 2.2.2. Incoming power for PBB, PCA, and ground power units (GPU) will be by Division 26 to separate lockable disconnects for them. Power will terminate in disconnect switches located on a new equipment rack under the existing fixed PBB. The PBB contractor will be responsible for extending power from these disconnect switches to the PBB, PCA and GPU. Provide in PBB panels and any transformers needed to adapt the terminal building power supply to meet the PBB requirements.
- 2.2.3. The apron drive PBB will operate on a 480 volt, 3 phase, 60 hertz, 60 amp circuit, with ground. This power will be derived internally and is part of the 200 amp, 480 volt service provided by Division 26 for the PBB.
- 2.2.4. Provide transformers and circuit breakers as required to transform the 480 volt, 3 phase power to 120/208 volt or 120/240 volt power as required for boarding bridge and fixed walkway power distribution.
- 2.2.5. All exterior electrical components will be housed in weather-tight, stainless-steel, and corrosion-resistant enclosures conforming to National Electrical Manufacturers Association (NEMA) 4X.
- 2.2.6. Provide two exterior heavy duty 36,000 lumen LED floodlights on the side of the bridge. Provide the Federal Aviation Administration (FAA) dusk to dawn photo controls.
- 2.2.7. Provide strain relief devices on all unsupported cables.
- 2.2.8. Provide cabling for the following across each bridge: Bridge power, including but not limited to, power, lighting, controls, and gate sign; Ethernet communication cable; 400 hertz frequency converter power; PCA unit power; smoke detector, alarm contact, collision avoidance system, and telephone. Cables will be flexible copper.
- 2.2.9. **Rotunda Column Grounding:** Provide a grounding stud on the rotunda base plate.
- 2.2.10. **Electrical Junctions:** All control wiring junction points, and connections within the boarding bridge, will be made directly to terminal strips, not by means of plug-type connections or splices.
- 2.2.11. Electrical connections between major bridge components/accessories and the bridge, such as horizontal and vertical drives, will be heavy-duty quick-connect type.
 - 2.2.11.1. Power cables will be hardwired from the PBB directly through rigid conduit to existing distribution panelboards or disconnect switches.
 - 2.2.11.2. All cables and wiring will be installed in cable carrying devices approved by the HAS Project Representative.
 - 2.2.11.3. All electrical switch and receptacle device plate covers will be stainless-steel. The device plate covers must match the device configurations, and on exposed wiring, will exactly fit the outlet box dimensions.
- 2.2.12. All electrical circuitry will be successfully tested before the unit leaves the Manufacturer's plant.
- 2.2.13. **Primary Power:** The main primary power, on indicator light, will be located on the operator's control panel adjacent to the on and off control switch.
- 2.2.14. **Anti-Chafing Devices:** Whenever electrical cables are required to slide or move; anti-chafing devices will be provided. Acceptable anti-chafing devices include grommets, flexible sleeves and jackets, and other similar approved devices.
- 2.2.15. Identify all cables with wire/cable identification bands on both ends. Bands will be pre-numbered plastic-coated style or type-on style with clear plastic self-adhesive cover flap, numbered to show circuit identification numbers indicated on shop drawings.
- 2.2.16. All Junction boxes will be labeled with engraved placards to indicate usage like 400 hertz, PCA, and bridge power.

2.3. Bridge and Fixed Walkway Insulation

- 2.3.1. Insulation will be provided in the ceiling and walls where applicable.
- 2.3.2. Insulation in ceilings will be 1-inch-thick, black, and mat faced fire-resistant fiberglass.
- 2.3.3. Insulation in walls will be 1/2 inches and must be provided with air space between the insulation and tunnel materials.
- 2.3.4. Insulation materials will not be exposed to the weather or applied with glues or tape.
- 2.3.5. All insulation materials will be covered with appropriate weather resistant finish material.
- 2.3.6. Insulation will be installed, full width of ceiling, with all areas insulated. Insulation will butt against light frame edges with a separate piece over light fixture.
- 2.3.7. The design must eliminate the possibility of condensation in the insulation. This could cause unsightly water stains appearing on the interior finished surfaces, rust at the interface of the insulation, and outer shell.
- 2.3.8. The use of asbestos or asbestos products as an insulation material, or for any other use, is not permitted.

2.4. Aircraft Cab

- 2.4.1. The cab will be equipped with a forward-facing operator control station, which is located behind a window to permit the operator full view of the aircraft contact area. Additional visibility will be provided through windows to the left side of the control station.
- 2.4.2. Cab roll-up side curtains will be aluminum slats. The left and right curtains will be equipped with interior weather seals and must be interchangeable. The exterior metal curtain covers will be full length with stainless steel hinged access panel.
- 2.4.3. Cab will be equipped with double swing doors or a roll-up door installed to seal the interior from outside weather conditions. The minimum door width will be 43 inches and a minimum height of 7 feet by 8 inches. Provide swing doors with return closure, stainless-steel kick plates on both sides, and deadbolt type latch.
- 2.4.4. The cab will be rotated by a gear motor and chain drive operating on the circumference of the fixed circular floor section of the aircraft cab. Adjustable limit switches and fixed physical stops will control the limits of rotation.
- 2.4.5. **Articulating Cab Floor:** The aircraft end of the cab will be provided with an automatic level device when the cab is rotated at an angle up to 95° off the centerline of the bridge tunnels.

2.5. Aircraft Closure (Canopy)

- 2.5.1. The aircraft end of the cab will be equipped with an adjustable closure with folded accordion bellows to make a weather-tight seal against the aircraft. Provide inner liner curtain that covers the canopy frame members.
- 2.5.2. The closure will be able to enclose both the open aircraft door, doorway of all aircraft served, and specifically the A380 aircraft.
- 2.5.3. The entire aircraft closure will be designed to be water-resistant, ultraviolet light rated, withstand weathering, remain elastic and flexible between -31°F and 127°F, be tear-resistant, and meet fire resistance requirements of NFPA 415. The aircraft closure color must be gray and approved by HAS.
- 2.5.4. Each side of the aircraft closure will use electrically, independently controlled and adjustable actuators, to permit the seal to conform to critical aircraft contours to provide a weather-tight seal. Provide means incorporated into each side of the closure mechanism to prevent excessive pressure on the aircraft. The

actuating mechanism will be designed to preclude excessive pressure on the aircraft fuselage.

- 2.5.5.** All actuators for the canopy, automatic leveling device, and other controls will be provided with rigid covers to protect them from passenger contact.
- 2.5.6.** Cushion pad seals will be provided at the point of contact, between the canopy and aircraft fuselage, to prevent denting and/or scratching of the aircraft skin, cabin, and cockpit windows. This includes damage to rain diverters or troughs that may be located over the doors. The seals that contact the aircraft must be segmented and attached to the main closure assembly by Velcro-type fastener strips.
- 2.5.7.** Canopy supports, or stiffening rods, will be thoroughly padded to prevent contact with the aircraft and protect canopy material when in its retracted position. The padding will be firmly attached in such a manner that it will not slip, turn, twist, or distort from repeated usage. Allow replacement of the padding sides, top, and inserts in sections without replacing the entire canopy.
- 2.5.8.** Changes in the position of the aircraft and/ or PBB while the canopy is in contact with the fuselage will not cause excessive loads to be exerted on the aircraft skin. Pressure exerted by closure against the aircraft fuselage will not exceed 2 pounds per square inch gauge (psig). Dependence upon the automatic leveling device to prevent such an occurrence is not acceptable.
- 2.5.9.** Any chains, cables, or electrical wire that penetrate the floor or wall structure must have adequate clearance, be protected, and be securely fastened.
- 2.5.10.** Cab seal will be resilient bellows type. Tarpaulin types are not acceptable.
- 2.5.11.** The canopy, when in its retracted position, will be protected by a hood or other device to prevent water from laying in the folds of the canopy material when the bridge is not in use. Exterior liner will include a third strap, made from the same material and size as the end straps at center of top canopy liner, or other suitable method to prevent water ponding.

2.6. Drive Column

- 2.6.1.** The drive systems will be electro-mechanical and meet the criteria listed below.

2.6.1.1. Vertical Drive - Electro-Mechanical:

- 2.6.1.1.1.** The bridge will be moved vertically by means of two recirculating ball bearing screw assemblies. Each assembly will be independent of the other, with individual motors. Each assembly will be capable of supporting the PBB and attached equipment, including PCA unit and 400 hertz GPU, under full design load. The lifting mechanism must hold its position at any elevation within the travel range with or without power supplied.
- 2.6.1.1.2.** The ball screw ball nut must be equipped with wiper brushes to remove grit or dirt from screw threads and a self-locking acme-type thread which will prevent unit collapse in the event of ball nut failure.
- 2.6.1.1.3.** The vertical drive motors will be Advisory Circular (AC) induction motors with integral reducer and brake. The brakes will be spring-applied and electrically released only when a signal is received from the operator's console or the auto- level system.
- 2.6.1.1.4.** The brakes will hold securely at all elevations, without creeping, whether the bridge is in operation or not.
- 2.6.1.1.5.** A fault detector must sense differential motion of the ball screw assemblies. The fault detector circuit will shut down the electrical power to the vertical drive motors and set the brakes independently of the operator if a fault is detected.
- 2.6.1.1.6.** A tapered collar that prevents the screw from disengaging the ball nut will be attached to the ball screw's lower end.
- 2.6.1.1.7.** Reference stripes will be painted or mechanically fastened on the inner tube(s) to indicate column travel limits, both high and low.
- 2.6.1.1.8.** Backup emergency, plunger-type, limit switches will be provided in the vertical circuit, for both high

and low limits.

2.6.1.1.9. Inspection holes in each column tube will be provided to allow borescope inspection of the ball screw surface. All holes must be aligned in inner and outer column tubes. Cover plates will be provided in the outer tube.

2.6.1.2. Horizontal Drive - Electro-Mechanical:

- 2.6.1.2.1. A variable speed, electro-mechanical drive system will provide horizontal travel of the PBB. The drive will be two-wheeled with solid tires.
- 2.6.1.2.2. An AC gear motor will independently drive each wheel and must be provided with integral brakes. Solid-state variable frequency motor controllers will drive the AC motors. The controller must provide built-in diagnostics to assist in trouble shooting.
- 2.6.1.2.3. A regenerative braking system will allow the bridge to come to smooth, controlled stops. Integral electrically-released spring actuated brakes must be provided with each drive motor and will lock the bridge in place whenever electrical power is cut off. This will be done either by moving the control lever to the neutral position or if power fails.
- 2.6.1.2.4. Provide a manual override to release the drive wheel brakes to permit towing the PBB into or out of position on the apron in case of power failure. The override system will be mechanically interlocked to preclude normal operation with the brakes locked out.
- 2.6.1.2.5. Connection lugs must be provided to allow the bridges to be towed in the event of power failures.
- 2.6.1.2.6. Provide positive identification for both the front and backsides of the wheel bogie. Such identification will be clearly readable by the operator while operating the control console.

2.7. Wheels and Tires

- 2.7.1.** Passenger boarding bridge wheels and tires will be of sufficient width and surface quality to preclude damage to apron pavement and must be designed to operate on Portland cement or asphalt pavement.
- 2.7.2.** The tires will be solid rubber with treads suitable for use by PBB. Tires will be manufactured of a rubber compound that will not chip or fray at the edges, and not be affected or damaged due to contact with oil, lubricating and hydraulic fluids, and/or fuels from aircraft and servicing equipment. This will include Skydrol hydraulic fluid.
- 2.7.3.** Each tire must be rated for wheel loading under full dead and live loading.
- 2.7.4.** Only the wheel to axle hub bolts/nuts will be able to be removed while the wheel is mounted on the wheel bogie. This will preclude accidentally loosening the tire from the rim while still mounted on the wheel bogie assembly.
- 2.7.5.** The wheel and tire changing procedures must be specified in the Maintenance Manual.
- 2.7.6.** Solid tires will have a projected life of more than 10 years.

2.8. Brackets for Equipment Mounting

- 2.8.1.** Provide factory installed mounting brackets for GPU, PCA unit, Automatic Docking System Controls, and PWC. Coordinate bracket requirements with manufacturer of each unit.

2.9. Controls

- 2.9.1.** PBB will be controlled by a PLC. Control system will have built-in triple protection against inadvertent

bridge movement due to a PLC input/output (I/O) fault.

- 2.9.2.** All PBBs shall have pre-positioning system with integrated VDGS controls.
- 2.9.3.** Locate all PBB operator controls on the bridge cab console, in a position that provides maximum operator visibility as the bridge is maneuvered near the aircraft with the cab weather door closed.
- 2.9.4.** Locate the operator control station to provide adequate space for the operator and maintenance access to the electrical control components as required by voltage classification in the National Electrical Code (NEC).
- 2.9.5. Control Console:** The control console will be in the operator compartment and protected from the outside environment. The control console must be tamper and theft proof. Provide two door locks, top and bottom, and hold open gas shock or other means to hold the door open. Provide hinged console face and support rods.
 - 2.9.5.1.** Provide lighted and labeled controls for all switches and indicators. Console will have a lamp test button to test all console lamps and alarms. Lamp test will be enabled in the operator switch “Off” position only, and must supply power to console lamps.
 - 2.9.5.2.** Provide a 5-inch liquid crystal display (LCD) monitor, mounted in the console face and closed-circuit surveillance camera with weather-tight enclosure, mounted under bridge near rotunda column to view the under-bridge area and PBB wheels (and aircraft wing for upper bridge) from the operator control station. Surveillance cameras will have dynamic contrast adjustment to provide high quality images in all ambient light conditions, including night time.
 - 2.9.5.3.** Provide a diagnostic touch screen with indicators, mounted in the console’s face to provide a graphical user interface to the PLC controls and for setting limits, viewing trouble logs, etc. Motion and accessory controls must be by pushbuttons and joystick, not by diagnostic touchscreen.
 - 2.9.5.4. Controls:** All PBB motion controls will be the momentary contact (dead man) type. All motion controls will be located to be relative to the function of the PBB being controlled like raise and lower functions, the “Raise” push button will be located above the “Lower” push button. The control console will include the following control switches and indications:
 - 2.9.4.4.1.** A three position key switch with positions marked Auto-level, Off, and Operate. The key will be removed only in the Off or Auto positions. The auto-leveler arm will extend when the switch is put in the Auto position.
 - 2.9.4.4.2.** A “Power-On” push-to-start button.
 - 2.9.4.4.3.** An “Emergency Stop” push/pull button.
 - 2.9.4.4.4.** A four way joystick will control going forward, reverse, and steering motions of the horizontal drive systems. As the joystick is moved progressively forward or back, PBB speed ramps proportionally through three preset speeds. Steering may be accomplished independently or at the same time by moving the joystick to the left or right.
 - 2.9.4.4.5.** Two individual push-buttons marked, “Raise” and “Lower,” are used to control the vertical travel of the bridge.
 - 2.9.4.4.6.** Two individual push-buttons marked, “Rotate Left” and “Rotate Right,” are used to rotate the cab.
 - 2.9.4.4.7.** Push-button(s) to independently control the adjustment of the left and right side of the bellows-type aircraft closure.
 - 2.9.4.4.8.** A switch to control the floodlights that illuminate the ramp area under the aircraft and drive column undercarriage.
 - 2.9.4.4.9.** A switch to control the cab floor deicer (if applicable). A switch to control the light in the cab.
 - 2.9.4.4.10.** A switch to change the adjustable cab floor operation from automatic or manual. The current mode of operation must be visually obvious.

- 2.9.4.4.11. A push-button switch to control the adjustable cab floor while in the manual mode.
- 2.9.4.5. Labeling:** All switches and/or push buttons will be labeled. Each function must be spelled out like canopy, extend, and retract.
- 2.9.4.6.** Warning devices, see indication method below unless otherwise noted:
- 2.9.4.6.1. A cab floor height indicator will show when the cab floor elevation is at the proper height, theoretically correct, for each aircraft to be serviced.
- 2.9.4.6.2. A wheel position indicator will show the orientation of the wheels along with the true tunnel centerline, regardless of the cab's rotational position.
- 2.9.4.6.3. An amber light to indicate that the auto level function is energized and operating.
- 2.9.4.6.4. An auto level malfunction will be indicated with a red light and must be accompanied by an audible warning.
- 2.9.4.6.5. A swing limit reached will be indicated with a red light on the console.
- 2.9.4.6.6. A red light will indicate when the aircraft closure is in the down position. Aircraft closure must be retracted before the bridge can be moved.
- 2.9.4.6.7. For electro-mechanical vertical drive systems, a red light will indicate a lift column malfunction has occurred.
- 2.9.4.6.8. A light will indicate if the cab floor deicer is on or off, if applicable.
- 2.9.4.6.9. If a pushbutton type switch is used, a light must indicate if the adjustable cab floor is in the automatic or manual mode.
- 2.9.4.6.10. On/Off switch, with light, for the rotunda roof mounted exhaust fan.
- 2.9.4.6.11. 60 watt flashing, amber rotating, beacon under cab when bridge is in Operation Mode only.
- 2.9.4.6.12. 110 volt travel alarm bell, 98 decibels (dB) at 10 feet.
- 2.9.4.6.13. All PBBs shall be equipped with Gate Management System to provide real time feedback from PBB, VDGS, PCA, GPU and integrate into BMS system
- 2.9.4.7. PCA Unit:** Provide controls to allow the operation of the precool/preheat function of the PCA unit in conjunction with the rotunda ventilator.
- 2.9.5. Interlocks:** For 400 hertz, jet hydrant fuel, cable hoist, water cabinet hoses and PCA units installed to serve the PBB, the units will be interlocked with the bridge control circuit so that the bridge cannot be moved away from the aircraft while these units are in operation and the cable hoist is not in the full (UP) position.
- 2.9.5.1. Alarms will be activated in the area of the loading bridge operator console, in the event that the bridge motion controls are activated if either of the above-mentioned conditions exist.
- 2.9.5.2. It is the responsibility of the Passenger Loading Bridge Manufacturer to ensure the compatibility of all bridge controls to be monitored via the HAS Building Management System (BMS).
- 2.9.5.3. The PBB manufacturer must coordinate with the PCA and 400 hertz supplier to monitor all vital functions of operations for each piece of equipment and integrate into the BMS.
- 2.9.5.4. Recommended monitoring points will be submitted for review and consideration. The airport reserves the right to change and/or modify each point for monitoring.
- 2.9.5.5. The PBB will interlock and be compatible with the Visual Docking Guidance System (VDGS) to notify the operator if the PBB is not in a safe position to allow aircraft docking.
- 2.9.5.6. **Contrary Control Signal Interlock:** All boarding bridge motion will be precluded whenever contrary control signals, extend and retract, are activated simultaneously.
- 2.9.5.7. **Control Console Doors:** Provide manual override safety interlock switches on all control console doors; upper console, console face, and console front door.
- 2.9.5.8. **Canopy Interlock:** Interlock will prevent all forward or reverse horizontal drive operation when the canopy is lowered. All PBB motion, except auto-leveling, will be possible only when the canopy is in a

fully retracted position. Provide for a dead man-type, mechanical override, to permit the retraction only in case of mechanical emergency or bridge failure with the canopy not in the fully retracted position.

- 2.9.5.9. **Auto-level Interlock:** No bridge movement will be allowed other than that signaled by the auto-level operation when bridge is in "AUTO" mode.
- 2.9.5.10. **PCA Interlock:** Interlock will prevent horizontal or vertical motion when PCA is operating. The control console will be equipped with a warning horn and flashing light to indicate when PCA is operating.
- 2.9.5.11. **400 hertz Interlock:** Interlock will prevent horizontal drive operation when the 400 hertz unit is engaged or the hoist is lowered. The control console will be equipped with warning horn and flashing light to indicate when:
- 400 hertz hoist is lowered.
 - 400 hertz cable is engaged and the unit is operating, to be independent of each other.
- 2.9.5.12. **Potable Water Interlock:** Interlock will prevent horizontal drive operation when the water cabinet doors are open.
- 2.9.6. Limit Switches:** Electrical limit switches will be provided on all PBB movement actuator systems, cab spacer, and canopy system. These must include fail-safe proximity limit switches activated near the end of horizontal and vertical travel. These switches will de-energize their respective actuator systems when contacted.
- 2.9.6.1. **Bridge Extension and Retraction:** Provide three limit switches, one proximity for slow down, one proximity for stop, and one mechanical for ultimate stop.
- 2.9.6.2. **Cab Rotation:** Provide limit switches to control the extremes of cab rotation.
- 2.9.6.3. **Drive Wheel:** Provide proximity limit switches to control oversteer of drive wheels.
- 2.9.6.4. **Rotunda Rotation:** The rotunda will be equipped with three adjustable limit switches in each direction to control the traversable area of the bridge: one proximity for slowdown, one proximity for stop, and one mechanical for ultimate stop in each direction. If the bridge activates the proximity for stop limit switch, travel in the limited direction will be disallowed. If the bridge activates the mechanical for ultimate stop due to failure of the proximity for stop, all power must be disconnected which will stop the bridge. The mechanical for the ultimate stop limit switch, located on the rotunda, will be reset locally by a bypass switch inside the control console.
- 2.9.6.5. **Tunnel slope:** Provide slope limit switch that allows tunnel slope to be adjusted from 10 percent slope up to 10 percent slope down. If limit switch is activated, travel in the directions of increasing slope will be disallowed.
- 2.9.6.6. **Cab Spacer:** Provide a minimum of three limit switches mounted on the cab spacer, or continuously across the front of the spacer, to stop the bridge when the spacer contacts the aircraft.
- 2.9.6.7. **Proximity Sensor:** Provide proximity sensor to detect when an aircraft fuselage is approximately 2 feet away from cab spacer. At this point, the bridge rate of travel must be slowed to not more than 6 feet per minute. Detection distance will be adjustable from 0 feet to 6 feet. Sensor will be rated for outdoor installation.
- 2.9.6.8. **45 Degree Sensors:** Provide two additional proximity sensors mounted on the cab's side at a 45-degree angle to activate slow down and stop functions when bridge is approaching aircraft at an angle. Sensors will be rated for outdoor installation. Distances will be set per PBB manufacturer's recommendations.
- 2.9.6.9. All infrared proximity sensors will be Sensopart FT 88 series or Perreri and Fuchs Series 28. Provide metallic shade over each sensor as required to prevent sensor blinding by sunlight. Control system must be programmed such that sensor trip initiate slow down or stop, as required, so that an inadvertent trip triggered by sunlight will initiate slow down or stop, as required.
- 2.9.6.10. **Bump Sensor:** Provide two bump sensors which stop bridge movement when the cab is at close proximity to aircraft.
- 2.9.7. Anti-Collision System:** Provide proximity sensors and interlock system to prevent collision of the bridge with aircraft, including wing and engines. Provide primary collision avoidance system to prevent collision

of new PBB and existing PBB. Install collision avoidance kit on existing bridge and upgrade existing controls as required. Also, install secondary laser collision avoidance system with sensors on each bridge as required per PBB manufacturer's recommendations.

2.9.8. Upper Console: Cabinet or housing for AC drive packs will be:

2.9.8.1. Waterproof

2.9.8.2. Equipped with a service light.

2.9.8.3. Equipped with a thermostatically controlled heat strip.

2.9.9. Automatic Leveling: Passenger boarding bridge will be equipped with an automatic leveling device. The auto-leveling system will automatically respond to small changes in aircraft elevation that occur during aircraft loading and unloading to maintain a constant relationship between the aircraft floor and the boarding bridge floor.

2.9.9.1. The auto-leveling system will be engaged when the master switch is positioned to "AUTO."

2.9.9.2. The leveling system will not exert any stress on the aircraft.

2.9.9.3. The leveling device actuating mechanism, or sensor which contacts the aircraft, must be located on the right side of the cab behind the canopy actuator cover.

2.9.9.4. The leveling system will function reliably on all aircraft specified regardless of door location, fuselage contour, aircraft doorsill height, and will allow a range of adjustment of at least 6 inches up or down from a neutral position.

2.9.9.5. The auto-leveler circuit will include an adjustable solid-state sustained travel timer. The timer must limit the automatic leveler's continuous response in either direction to an adjustable range from 1.6 to 6 seconds. A fault condition must be identified when the timer has tripped. Upon sensing of a fault condition, all motor power will be disconnected, audible, and visual alarms must be energized at the control console. There must be an additional audible and visual alarm at the rotunda, and a red warning light, bell or horn in the general ramp area, which will produce a distinctively different sound than any other on the PBB.

2.9.9.6. When the timer circuit is interrupted, the vertical lift system will automatically be locked in position and de-energized, and a vertical travel brake automatically engaged.

2.9.10. PBB Service Door Platform and Emergency Egress Stairs Platform, Fixed Walkway: Weatherproof fluorescent light and wire caged, will be controlled by photocell for automatic operation at night.

2.9.11. Cab Ceiling Exterior Fluorescent Light: Two bulb sealed, 48 inch, and 32 watt light.

2.9.12. Cab Undercarriage Exterior Flood Lights: Minimum of two 2,600 lumens LED fixtures, wire caged, lights to illuminate apron ahead of PBB.

2.9.13. Tunnel Undercarriage Flood Light: 2,600 lumens LED fixtures, wire caged, lights to illuminate drive column wheel bogey area.

2.9.14. Obstruction Light: The obstruction light a 360° visible red, weatherproof, light-emitting diode (LED) light mounted on top of the cab's right side.

2.9.15. Ramp Lighting Under Fixed Walkway: 1,600 lumen LED canopy light, attached underneath the fixed walkway, placed 10 feet from each end of the fixed walkway, and every 20 feet in between. Coordinate light fixture housing color with Architect.

2.9.16. Lighting KPS 100-M R5 120 or Equal: Lights will be controlled by photocell under fixed walkway.

2.9.17. Apron Flood Lights: Provide two heavy duty 36,000 lumen LED floodlights with #FRWB wall bracket. Wall mount will be on the exterior east wall. Provide FAA dusk to dawn photo control.

2.9.18. Ventilator: Provide a 3,000 cubic feet per minute (cfm) power ventilator installed on the roof of the rotunda for use with bridge precooling/preheating. Ventilator will be equipped with a back-draft damper. If centralized PCA system is used, These Passenger Boarding Bridges should be designed with a custom fabricated ductwork system that fits the telescoping bridge so that there will not be a need for rooftop dx unit.

- 2.9.19. Cab Floor Heater:** Provide 240 volt, 1.75 kilowatt (kW) minimum cab floor heater with a manual control switch and indicator light located in the control console. Provide a minimum 20 amp circuit breaker and thermostatically controlled or self-regulating heater mat. The “On/Off” switch must be accessible by service personnel only.
- 2.9.20. Cab Safety Chain:** Provide cab safety chain installed forward of the cab doors with a red plastic sleeve.
- 2.9.21. Mirrors:** Provide two, 18-inch circular convex safety mirrors with stainless-steel backing.
- 2.9.21.1.** Locate mirrors on the left side of the cab to enable the operator to have full view of the apron, drive wheels, and service platform railing to allow operator to view the bottom of the service stairs from the control console.
- 2.9.22. Handrails:** Interior tunnel handrails must be American with Disabilities Act (ADA) compliant (1-1/4-inch to 1-1/2-inch outside diameter (O.D.), mounted at a height of 34 inches to 38 inches above floor surface, with a clearance from the sidewall of 1-1/2 inches, and with return ends. Handrails must be brushed aluminum.
- 2.9.23. Fall Protection:** The roof of the cab and rotunda will have metal safety connection rings and the roof of each bridge section will have a cable safety line for Occupational Safety and Health Administration (OSHA)-compliant fall protection.
- 2.9.24.** PBB precooling/preheating grille and connection to preconditioned air unit. The grille will be mounted as far forward as possible in order to allow precooling/ preheating with the bridge fully retracted.
- 2.9.25. Gate Sign:** Provide an illuminated gate sign, mounted on the top of the PBB cab, identifying the appropriate gate number. The sign lens will be a minimum of 2 feet, 5 inches high by 4 feet, 3 inches long and must have 2-foot-tall gate numbers. The character font must be Swiss 721 Heavy Bold Type (BT). The sign configuration type and font color will conform to HAS Standards.
- 2.9.25.1.** The sign must be mounted on a pivot bracket mounted to the rooftop of the bridge cab. During installation, rotate the gate sign to the desired final position before tightening cap screws on the pivot bracket. Sign housing will be painted to match the bridge color. The sign must house a 400 watt metal halide bulb as manufactured by General Electric, Model MPR400-VBU-XHOPA, or equal. Provide all electrical conduit, wire, and connections required for a complete and operable installation.
- 2.9.26.** The transition area accommodates the difference in elevation where telescoping tunnel sections overlap. This area consists of a section of floor that is sloped gradually, with respect to the tunnel centerline, and a hinged transition ramp. The sloped section conforms to the NFPA 415 requirements. The interface joints between the tunnel sections are bridged by smooth, very low slope floor inter-ramps. This achieves the requirement for a safe and secure transfer of passengers, without the need for handrails.
- 2.9.27.** The walls of the telescoping tunnel sections will be designed using heavy-duty, horizontal structural tubes, and angles that are combined to form built-up members that are positioned at the roof and floor. The horizontal tubes must be welded together with diagonal truss type connecting tubes to develop a heavy-duty truss wall design. Structural tubes will be selected to minimize corrosion and water accumulation. Tie rod designs will not be permitted. The tube design will produce a clean, open truss design, providing a less restricted view of the apron activities for the passengers. The roof of each tunnel section must be manufactured from 14 gauge galvanized steel panels attached to a framework of angle and tubing. These panels are formed, spot welded, sealed and painted, designed to provide a flat, smooth profile that is slightly crowned in the center to facilitate water run-off. All vertical loads of the PBB will be carried by a roller mechanism, located at the top and bottom section of the tunnel walls. The walls of the tunnel sections must be clad with laminated double glass panes. These panes consist of an outer laminated pane, 8 millimeters), an inner colored pane, 6 millimeters, and an intermediate 8 millimeter air gap. Both panes are of tempered safety glass. The glass panels are installed so that there is adequate space between the interior of the glass panels and the structural tubing to allow thorough cleaning. The design must allow for the differential expansion of the glass wall, molding, mullions, and truss structure of the bridge, so that no abnormal stresses are placed upon any single member of assembly of the boarding bridge.
- 2.9.28.** The walls of the tunnel sections will be clad with double-pane glass with fretting and double-glazed unit

with desired minimum U factor 1.03

2.10. Function

- 2.10.1. Bridge-Installed Equipment:** Coordinate the installation of the 400 hertz GPU, cable hoists, PCA unit, hose baskets, PWC, building supplied electrical, and communication services with installation of the PBB and fixed walkway.
- 2.10.2. Telescoping Tunnel Slope:** Maximum slope will be 8.3 percent (1:12) measured along the tunnel floor, except at the transition ramps, for each aircraft type serviced.
- 2.10.3. Cab Rotation:** The cab will be designed to rotate a total of 125°, 90°-95° counterclockwise and 30°-35° clockwise from center, at a maximum speed of 145° per minute in either direction.
- 2.10.4. Bridge Rotation:** The rotunda will permit the entire unit to rotate 175°, 87.5° clockwise and 87.5° counterclockwise.
- 2.10.5. Drive Wheel Rotation:** Steer angle must be 180° in place and in motion. Steer speed will be 23° per minute.
- 2.10.6. Vertical Lift Speed:** 2.5 feet per minute (fpm) to 4 fpm as measured at the cab spacer.
- 2.10.7. Drive Speed:** The drive system will permit the unit to extend, retract, and rotate to any point within its operating envelope at a variable speed between 0 and 90 fpm.
- 2.10.8. Deceleration:** The horizontal drive system must include a decelerator device to reduce or eliminate shocks when approaching maximum extension, retraction, or when horizontal travel is stopped or reversed suddenly, for protection of the equipment and PBB operator.
- 2.10.9. Loads:** In addition to the dead loads and dynamic effects caused by movement, the entire PBB and fixed walkway will support the following minimum loads and those of all attachments to the bridge and fixed walkway. Unless the governing building code prescribes more severe requirements. These loads may be applied in total or in part, singularly, or simultaneously. The design must be based on the combination that imposes the most adverse loading.
- 2.10.10. Live Load PBB (Extended or Retracted) and Fixed Walkways:** 40 pounds per square foot (psf)
- 2.10.11. Wind Load:** Retracted and Stowed: 25 psf, or an approximate wind velocity of 100 mph, 3 second duration. Operational: 12.5 psf, or an approximate wind velocity of 60 mph.
- 2.10.12. Roof (Snow) Load:** 10 psf and the ability to support a 300 pound person at any location on the roof.
- 2.10.13. Equipment Minimum Loads (Approximate):** To be determined by Bridge Supplier. PCA Point-of-Use Unit: 7,000-10,000 pounds aft of the drive column, mounted under the PBB. Hose Reel and Hose: 350 pound 400 hertz Power Unit: 2,750 pound 400 hertz Cable Hoist: 600 pound PWC: 300 pound mounted on the lift column.
- 2.10.14.** The structural design will provide sufficient torsional rigidity to minimize sway when the boarding bridge is brought to a gradual stop.
- 2.10.15.** All mechanisms for actuating, guiding, and restraining the boarding bridge and its components will be designed to minimize the noise, deflection, and vibration apparent to passengers. No operating vibrations or loads must be transmitted to the terminal building or fixed walkways.
- 2.10.16.** The rotunda entry corridor will be a fixed rectangular tunnel at a constant height that connects the terminal building or fixed walkway with the rotunda.
- 2.10.17.** The rotunda entry corridor must be cantilevered from the rotunda column to the mating frame of the fixed walkway.
- 2.10.18.** Provide flashing to create a weather-tight connection between the rotunda entry corridor and the fixed walkway. Flashing will be sloped so it will not trap or pond water. Provide interior metal flashing to allow bridge movement. Interior metal flashing must be painted to match the PBB interior and will be connected only to the corridor, not to terminal building, and must have felt backing on the fixed

walkway interface side to prevent chafing of the terminal.

- 2.10.19. Door Threshold:** Install a threshold at the fixed walkway/boarding bridge that allows for bridge movement. The threshold must be aluminum diamond plate.
- 2.10.20.** The rotunda will be a cylindrical structure supported on a tubular column. The rotunda floor must remain level at all positions and will be installed at the same elevation as the fixed bridge.
- 2.10.21.** Flap-type seals (dual) will be provided for complete weather tightness between the rotunda and the hinged telescoping tunnels.
- 2.10.22.** Rotunda side curtain must be aluminum and be provided with adjustable tensioning devices, positive tracking system, and interior weather seals. The exterior metal curtain covers will be full length, with stainless-steel hinged access panel, to allow access to curtain idled barrel grease fittings.
- 2.10.23.** The rotunda and fixed walkway support columns must not be anchored or secured to the terminal building, nor will they transmit any live loads, dead loads, or vibrations to the terminal building.
- 2.10.24.** An industry standard #7, eight-bolt foundation pattern will be used, or as required to resist the structural live and dead loads specified.
- 2.10.25.** Coordinate and verify quantity, location, and details of foundation design prior to fabrication.
- 2.10.26.** Provide eight, 2-1/4-inch, 4-foot-long anchor bolts per support column, to foundations contractor, prior to pouring concrete footings and bases.
- 2.10.27.** Telescoping tunnels will be rectangular in cross-section, constructed of metal panels, and hinged at the rotunda end for vertical motion.
- 2.10.28.** Fixed walkways will be of similar construction to that of the telescoping tunnels (Airport/project specific).
- 2.10.29.** Minimum inside dimensions of the fixed walkway will be: minimum height – 7 feet 7 inches, minimum width, clear wall width – 6 feet 10 inches, and handrail-to- handrail – 6 feet 3 inches.
- 2.10.30.** Provide exterior flashing to create a weather-tight connection between the fixed walkway and the terminal building. Flashing will be sloped so as not to trap or pond water. Provide interior metal flashing, paint it to match the PBB interior, and connect it only to the fixed walkway, not to the terminal building. The interior flashing will have felt backing on the terminal building interface side to prevent chafing of terminal. Coordinate terminal flashing attachment method with the HAS Project Representative.
- 2.10.31. Terminal Door Threshold:** Install a threshold at the terminal door/fixed walkway interface, which will allow for fixed walkway movement and building settlement. The threshold must be aluminum diamond plate.
- 2.10.32.** Provide a ceiling mounted, weathertight 36-inch by 26-inch access hatch for maintenance to each roof-mounted direct expansion (DX) cooling unit, quantity of three. Provide an OSHA rated roof mounted tie-off for personal protection, and maintenance ladder with cage and tie-off down to the apron.

2.11. Serviceability

- 2.11.1.** Maintenance requirements will present no special problems to personnel knowledgeable in their respective fields of hydraulics, electrical power and controls, or general mechanical assembly.
- 2.11.2.** Install bridge and fixed walkway components with adequate access and appropriate fastener types to permit change-out by one person. If a component's weight requires mechanical assistance to lift the component, assembly will be provided with lift eyes, fork lift guides, or other means of providing a mechanical advantage. Components must be simple, rugged and easily accessible for routine maintenance, lubrication, exchange, and adjustment. Electrical cabinets, hydraulic cabinets, and pumps will be located so they are always accessible to maintenance personnel. All interior electrical

cabinets must have a door-operated light for illuminating all interior components.

- 2.11.3.** Access panels, where required to gain access to equipment or maintenance areas, shall be sized to allow necessary tools and equipment to be inserted to complete the work. The panel must be permanently attached to the structure by stainless-steel hinges, and any fasteners required must be stainless steel, permanently affixed to the panel.
- 2.11.4.** Provide all product specific tools required for routine maintenance.
- 2.11.5. Modular Components:** Utilize standardized modular components, that are readily available in the continental United States, to provide rapid corrective measures of malfunctioning critical components. Critical bridge components must be accessed and installed easily.
- 2.11.6.** All hardware items required including, but not limited to, bolts, studs, nuts, washers, and fasteners will be provided in inch or pound unit sizes. Exterior hardware and fasteners will be stainless-steel where practical.
- 2.11.7.** The manufacturer must maintain an adequate inventory of all proprietary or vendor fabricated, and modified parts, for routine maintenance of the unit. All stock must be maintained, whether or not the unit is in current production, for a minimum of 10 years from date of the last unit supplied.
- 2.11.8.** All mechanical and electrical systems will be protected from potential damage resulting from climatic conditions, falling objects or collision with aircraft service equipment, and other moving vehicles.
- 2.11.9.** All cable ties, fasteners, and other items subject to direct or indirect sunlight will be ultraviolet light rated.

Part 3 – Execution

3.1. Installation

- 3.1.1.** Six weeks prior to shipment of boarding bridges, notify the HAS Project Representative and arrange a factory pre- shipment inspection by HAS personnel or designated agents.
- 3.1.2.** The inspection will provide both documented and visual confirmation that units being inspected have successfully passed all required tests and certifications, and components and finish quality standards have been provided for and complied with as noted in this Standard. The units need not be operational at the time of the inspection, but all elements of the boarding bridge must be fully accessible and visible for the inspection.
- 3.1.3.** Inspectors will include, but not necessarily be limited to, the following:
 - HAS Representative(s).
 - HAS Maintenance Supervisor.
- 3.1.4.** HAS may reject the boarding bridges for non-compliance with the specifications.
 - 3.1.4.1.** Corrective replacement, repairs, or refinishing must be undertaken immediately after rejection.
 - 3.1.4.2.** No claims for additional cost or extension of the schedule, will be permitted or awarded for the time, cost, or effort necessary to correct defective or faulty work.
- 3.1.5.** HAS reserves the right to conduct additional pre-shipment inspections for any and all boarding bridges.

3.2. Testing

- 3.2.1. Test Reports:** Submit all factory and field test reports to the HAS Project Representative prior to the final inspection.

3.2.2. All operating mechanical and hydraulic components will be assembled and tested before the unit leaves the manufacturer's plant. The PBB manufacturer will include pricing for factory witness testing of the submitted units. Witness test to include travel and accommodations for three project representatives, either HAS or Designer. Hydraulic cylinders will be designed for seal replacement by maintenance technicians.

3.3. Training

3.3.1. Furnish upon delivery of PBB and fixed walkway, three copies of technical manuals for the equipment furnished under the project. Manuals will not be generic in nature and must reflect the exact construction of the bridge and fixed walkway furnished. Non- applicable items and drawings will not be included in the manuals. Manuals may have descriptive type photographs, and pages must have reinforced edges. Manuals will be compact in size and bound. Manufacturer must also transmit all listed manual information in electronic pdf format.

3.3.2. The technical manuals will comply with the Air Transport Association of America (ATA) Specification 101 and contain the following information:

3.3.2.1. Description and operation of all systems and components.

3.3.2.2. Electrical drawings specific for the bridge and fixed walkway furnished. Provide one set of bound, laminated, electrical drawings for each bridge to be placed in the control console. Provide one set in each technical manual.

3.3.2.3. Maintenance instructions including troubleshooting/diagnostics guidelines.

3.3.2.4. Overhaul instructions.

3.3.2.5. List of parts and part numbers.

3.3.2.6. Illustrated parts list of all components.

3.3.2.7. Recommended spare parts list and sources.

3.3.2.8. Complete and detailed Preventive Maintenance Program for boarding bridge furnished for the project.

3.3.2.9. Training: Submit a detailed description including agenda and duration of training proposed.

3.3.3. Provide the following materials for bridge and fixed walkway at installation:

3.3.3.1. Spare fuses, minimum one each size.

3.3.3.2. Paint touch-up kit, full and unopened.

3.3.3.3. Aircraft closure, canopy, repair kit. No less than 2 percent of each, one of each minimum, wall panel type and mounting/trim accessories. Furnish replacement panels and accessories from same production run as materials installed. Materials will be protected and labeled as replacement materials.

3.3.4. Provide one complete set of the following materials at installation:

- Bridge rollers
- Interior light diffusers
- Bridge controls spare parts as recommended by the manufacturer.

35- IRRIGATION AND LANDSCAPE



35 - Irrigation and Landscape

Part 1 – General

1.1. Overall

- 1.1.1.** A landscape plan for each site will be submitted with the site plan.
- 1.1.2.** Plant material specified will be in accordance with the United States Department of Agriculture (USDA) Plant Hardiness Zone Map for the local area. Vegetation that produces seeds, fruits, or berries, or that provides dense roosting or nesting cover shall not be used.
- 1.1.3.** For turfing:
- Bermuda, Coastal Bermuda, and/or Saint Augustine Grass shall be used for sodding
 - Bermuda and/or Coastal Bermuda shall be used for sprigging
 - A mix of Bermuda, Coastal Bermuda, Carpet grass, Centipede, and/or Zoysia shall be used for warm season hydroseeding
 - A mix of Chewings Fescue, Kentucky Bluegrass, Red Fescue, and/or Tall Fescue shall be used for cool season hydroseeding
 - Additionally, erosion control blankets shall be used overtop of the hydroseeding
 - Millet or any other large-seed producing grass shall not be used for any application
- Plant selection will be reviewed and approved by the Houston Airport System (HAS) Horticulturalist and the HAS Wildlife Biologist. Prior to installation, all plant material is subject to inspection by the HAS Horticulturalist for disease, pest, and overall health.
- 1.1.4.** All newly installed turf will need to be watered consistently every day for 20 minutes for the first 2 weeks and then every other day for 4 weeks. After week 4, watering needs to be done 3 times per week until the end of the 16th week. Rain events may reduce the frequency of watering required. Watering may be done by:
- Hand watering with a hose and attached sprinkler
 - Water truck/tanker
 - Temporary/permanent watering system using a battery-operated controller attached to a water source
- The watering plan will be reviewed and approved by the HAS Horticulturalist.
- 1.1.5.** Installation of automatic watering systems is required for the entire area along entrance roadways, the infield areas, and any designated landscape areas. Outlying areas such as the secondary service roads in support areas, perimeter planting areas, and airfield grass areas do not require sprinkler systems. Watering of trees in all areas will be necessary for the first two years after initial planting.
- 1.1.6.** The landscape plan for each site should target to reduce the water requirement by at least 50 percent from the calculated baseline for the site's peak watering month. Plant species selection and irrigation system efficiency as calculated in the Environmental Protection Agency (EPA) WaterSense Water Budget Tool should be prioritized first.
- 1.1.7.** All landscape installations, including turf, trees, & shrubs, shall be warrantied for at least one year.

1.2. Quality Assurance

- 1.2.1. Prior to issuance of a permit, a letter from the Designer's Engineer of Record must be on file confirming that the irrigation design is in accordance with Texas Commission on Environmental Quality (TCEQ) Chapters 210 (Reclaimed Water) and 344 (Landscape Irrigation).
- 1.2.2. Prior to issuance of a Certificate of Completion, a letter from the Contractor must be on file confirming that irrigation construction and operation conform to the approved contract documents. The Designer must certify to the placement and operation of the system.

Part 2 – Products

2.1. Information

- 2.1.1. Turbo water meters with strainer, Remote Transmitter Receiver (RTR), and pit electronics with data profiling capabilities for reclaimed water are required. The meter register must be purple in color and properly stamped for reclaimed water.
- 2.1.2. Temporary reclaimed water or irrigation systems used to establish the growth of turf in airfield areas require special consideration. Approval by the HAS Operations Department is necessary prior to final design.
- 2.1.3. All irrigation will be installed with sleeving for newly-developed areas, so that sprinkler systems can be incorporated without the disruption of transportation systems. It is required that purple polyvinyl chloride (PVC) piping be used in general planting areas.
- 2.1.4. All irrigation controllers will be mounted in stainless steel cabinet models, preferably installed outside of the facility. All irrigation satellite controllers must be connected to a Cluster Control Unit (CCU) by a two-wire path. All new sites must have a CCU with a stainless-steel cabinet and two-wire paths to each satellite controller. Each CCU must have a compatible freeze sensor and rain sensor.
- 2.1.5. Freeze sensors will have a temperature set point of 37.4°F, 24 Volt AC, 6 amp rating, and closed above 37.4°F and open below 37.4°F. Freeze sensor will be mounted at a height and location that is out of direct sunlight and where free outdoor air circulation is possible. Each freeze sensor must be attached by a two-wire path, no lighter gauge than 20 American Wire Gauge (AWG), to a sensor decoder. Sensor decoders must be housed in the base of a stainless-steel controller cabinet, within an existing satellite controller cabinet, a CCU cabinet, or a separately installed cabinet. The sensor decoder will also be connected to the two-wire path.
- 2.1.6. Rain sensors will be a tipping bucket/ magnetic reed switch style, rainfall per tip is 0.01 inch. Each rain sensor must be attached by a two-wire path, no lighter gauge than 20 AWG, to a pulse decoder. Pulse decoders must be housed in the base of a stainless-steel controller cabinet, within an existing satellite controller cabinet, a CCU cabinet, or a separately installed cabinet. The pulse decoder will also be connected to the two-wire path.
- 2.1.7. Wiring will be 12-gauge underground feeder (UF) irrigation wire, using 3M brand, DBY or DBR (direct bury) connectors.
- 2.1.8. Valves
 - 2.1.8.1. All gate valves of 4-inch or 3-inch size will have standard cube head on stem. Valve stacks will be a standard cast iron, or equivalent, with an appropriate cast iron lid. All electric valves will be enclosed in a standard 10-inch valve box.
 - 2.1.8.2. All remote control valves, isolation valves, pressure valves, altitude valves, and reducing valves for on-site reclaimed water systems, will be installed below grade in a valve box.
 - 2.1.8.3. Flush lawn quick coupler valves will be provided in all landscape planted areas.

- 2.1.8.4. All quick couplers will be located so that all trees and planting areas can be reached by a 100-foot length of hose.
- 2.1.8.5. All quick coupling valves, for reclaimed water, will be specifically for reclaimed water use. The quick coupling valve must be a two-piece, capable of having a discharge rate between five and 100 gallons per minute (gpm) with a maximum working pressure of 150 pounds per square inch (psi). The valve will be constructed of heavy cast brass and will have a purple, thermoplastic, locking rubber cover with molded wording “Do Not Drink- No Tomar” in English and Spanish. It will also have universal symbol for non-potable systems imprinted on the locking cover. To prevent unauthorized use, a special coupler key for opening and closing the valve will be provided for the exclusive operation of the valve.
- 2.1.8.6. Quick coupling valves for reclaimed water must be installed approximately 2 inches from walks, curbs, and paved areas. Quick coupling valves used in the reclaimed water system must be installed in a valve box marked, “Reclaimed Water,” and a reclaimed water identification tag must be permanently attached to the quick coupler valve so that it is clearly visible when the box lid is removed.
- 2.1.9. Irrigation Water Piping:** All pipe and fittings will be Schedule 40 PVC.
- 2.1.10. Reclaimed Water Piping:** All pipe and fittings will be Schedule 40 purple PVC.
- 2.1.11.** All sites using reclaimed water must post clearly visible standard sized, 12 inch by 9 inch, advisory signs indicating the use of reclaimed water. The signs must be installed at all entrances to the customer’s facility where they can be easily seen to the extent necessary to advise passersby. Signs must be placed no further than 1,000 feet apart. For medians, a sign will be placed at the beginning and end of every median. The lettering on the signs must be a minimum of ½-inch high and must be black or white on a purple background. The sign must also include the name of the water agency. Where required for aesthetic or corporate identity purposes, alternate color-coding schemes may be adopted, subject to the approval of HAS Airport Water Agency.
- 2.1.12.** Above-ground reclaimed water pipe lines, whether new or existing, must be labeled with the words “Reclaimed Water-Do Not Drink-No Tomar.” The label must be colored purple to differentiate reclaimed water pipelines from potable water pipelines. If purple identification tape is used to label the pipe and/or color code the pipe, the tape must be adhesive, permanent, and resistant to the environmental conditions. Purple bands may also be painted around the circumference of the pipe at 10-foot intervals for color coding.
- 2.1.13. New Buried Reclaimed Water Lines:** The use of purple pipe and sprinkler heads will be the preferred method for identification of new buried reclaimed water piping, both constant pressure mainlines, and intermittent-pressure laterals.
- 2.1.14.** Existing buried piping, which will be converted to reclaim water use, need not be marked unless the piping becomes exposed. Examples would be installation of new pipeline, modification of the system, or maintenance of existing pipe. Purple reclaimed water identification tape, used above or wrapped around the pipe, will be the preferred method.
- 2.1.15. Reclaimed Water Sprinkler Heads:** The preferred method for existing sprinkler heads that will be distributing reclaimed water will be identified with purple rings attached to the top of the heads.
- 2.1.16.** All reclaimed water system controllers must be identified by affixing a sticker, or nameplate, to the inside and outside of the controller cabinet enclosure. Stickers or nameplates must be weatherproof and must contain wording in English and Spanish. They must also indicate that the controller is for reclaimed water system use.
- 2.1.17.** Valve boxes for reclaimed water, purple valve boxes, will be used and must have an advisory label or nameplate permanently molded into or affixed onto the lid. They must be affixed with rivets, bolts, etc., and will be constructed of weatherproof material with the wording “Reclaimed Water – Do Not Drink – No Tomar” permanently stamped or molded into the label.

- 2.1.18.** New and existing isolation valves must be installed in a marked valve box with a reclaimed water identification tag on the valve operator or if the valve operator is too deep to reach, at the top of the valve extension. New and existing remote control valves will be installed in a marked valve box with reclaimed water identification tag on the box lid and valve. The remote control valves will be enclosed in a standard 10- inch valve box.
- 2.1.19. Reclaimed Water Storage Facilities:** All storage facilities must be identified by signs and labeled with words "Caution: Reclaimed Water," "Do NOT Drink – Unsafe Water," "No Tomar," or similar wording.
- 2.1.20.** The large open grass areas, along primary roads, will be irrigated with rotor type heads distributing water from 40 to 90 feet in diameter, depending on the available pressure. Sprinklers of substantial construction will be used to withstand the abuse normally associated with heavy maintenance equipment. These rotor heads will be on Schedule 80 swing joints.

2.2. Function

- 2.2.1. Potable Water Line Separation:** Reclaimed water piping will be separated from potable water piping by a horizontal distance of at least 9 feet. Where the 9 foot separation distance cannot be achieved, the reclaimed water piping must meet the line separation requirements of TCEQ Chapter 290. After separation from the potable water line, the existing irrigation tap will be capped at the potable water main and any existing pipe removed.
- 2.2.2.** Where a reclaimed water line parallels a sewer line, the reclaimed water line will be constructed in accordance with subsection E or F of the Texas Administrative Code. The horizontal separation distance will be 3 feet (outside to outside) with the reclaimed water line at the level of or above the sewer line. Reclaimed water lines, that parallel sewer lines, may be placed in the same benched trench.
- 2.2.3.** All reclaimed water distribution systems must be designed to prevent operation by unauthorized personnel.
- 2.2.4.** Irrigation piping will not be installed on top of roadway slopes or along retaining wall toes, unless cut-off valves are positioned at lower levels and away from structure.
- 2.2.5.** Longitudinal deflection at each pipe joint will not exceed 1 degree in any direction.
- 2.2.6.** Small grassed areas which occur adjacent to roadway paving, will be sprinkled with smaller diameter pop-up heads so that close control can be maintained on wind-blown mist. All pop-up spray heads will be supplied with the appropriate nozzles and nozzle screens.
- 2.2.7.** Groundcover areas, along all access roads and in the fields, will be irrigated according to the size of the planting areas and obstructions within these areas. The groundcover, under planting for the trees, will require sprinklers with appropriate spacing and proper nozzles, to provide adequate coverage. Large open plantings of groundcover will incorporate rotor type heads with proper nozzles for proper coverage.

2.3. Serviceability

- 2.3.1.** All pipe and fittings will be Schedule 40 Purple PVC. This provides common equipment throughout the Airport facilities, allowing maintenance personnel to make necessary repairs while maintaining a quality system.

2.4. Durability

- 2.2.8.** The irrigation system will be designed to prevent incidental ponding or standing water, and will be managed to minimize the inadvertent contact of reclaimed water with humans. Irrigation systems will be designed so that the irrigation spray does not reach any privately-owned premises outside the designated irrigation area or reach public drinking fountains.

Part 3 - Execution (Not Used)

36- PRE-CONDITIONED AIR UNITS AND ACCESSORIES



36 - Pre-conditioned Air Units and Accessories

Part 1 – General

1.1. Overall

1.1.1. This Standard describes point-of-use or centralized pre- conditioned air (PCA) units and accessories to be specified by the Designer and installed by the Contractor.

1.1.2. This Standard includes the design, installation, testing, and commissioning of point-of-use (POU) direct expansion (DX) or centralized PCA units for installation on passenger boarding bridges (PBBs). This includes all equipment necessary to provide a complete and operational PCA unit(s) including start- up services, and warranties as specified. The following types of equipment and accessories are included:

- PCA units
- Aircraft adaptor nozzles
- PCA hose baskets
- Flexible aircraft duct (hose)
- Hose reels

1.1.3. Refer also to Volume 10, Article 15, 1.1.1.3. Passenger Boarding Bridges.

1.2. System Description

1.2.1. Design Parameters:

1.2.1.1. The PCA units will match the aircraft types planned for the gates as shown on the drawings and in these specifications.

1.2.1.2. Each PCA unit will have dual discharge hoses for aircraft service.

1.2.1.3. Design Aircraft:

- Airplane Design Group (ADG) VI: A380 and large 747.
- ADG IV: B787, B-767.
- ADG V: A-330, A-340, A-350, B-747, B-777.
- ADG III: A-320, B-737, MD-80.

1.2.1.4. The A380 aircraft requires four PCA connection points, serviced by two sub- freezing PCA units, and will be provided with an A380 and aircraft model selector switch.

1.2.1.5. The PCA unit selector switch will control the airflow, pressure, heating, and cooling capacity of the PCA unit based on the type of aircraft selected. This way the unit can deliver PCA within the range of design parameters and without exceeding airflow, pressure, or temperature limitations of the aircraft.

1.2.1.6. Precooling/preheating will be provided for each PBB controlled at the console.

1.2.2. The Contractor will provide all material, equipment, and labor for the complete installation of the PCA unit components on the PBB serving the aircraft at each gate. In general, the work on the bridges includes:

- 1.2.2.1. PCA unit and all required accessories for a complete operating system
- 1.2.2.2. Supply air distribution system, comprised of rigid ductwork (if required), flat flexible duct (hose) extension with aircraft mating nozzle, and hose storage basket
- 1.2.2.3. Condensate drain pan, pump, and tubing to discharge generated condensate back across the PBB
- 1.2.4.** Design day ambient conditions at Bush Intercontinental Airport (IAH), Houston, TX:
 - Summer: Dry Bulb (db) Temperature: 98°F
 - Summer: Wet Bulb (wb) Temperature: 80°F
 - Summer: Maximum Temperature: 120°F
 - Winter: db Temperature: 20°F
- 1.2.3.1. **Aircraft Cabin Design:** Cabin design temperature will be as per airplane manufacturer's recommendations.
- 1.2.3.2. Cooling capacity and flow characteristics will be based on published cooling demands by aircraft manufacturers.
- 1.2.3.3. PCA units that service the A380 will deliver sub-freezing air, will be sized for one-half of the A380-800's overall cooling load; 100 percent passenger and crew load, 50 percent electrical load, maximum solar load, design ambient temperatures, and 100 percent outside air for peak cooling capacity.
- 1.2.3.4. PCA units will be sized to use 100 percent outdoor air. Return air to the air handling unit will not be used.
- 1.2.3.5. PCA unit design will provide the static pressure at the outlet of the PCA ducting to meet the requirements of all aircraft that may be parked at the gate but will not over pressurize the aircraft. The PCA unit will be designed to provide the cooling capacity listed at the aircraft connection, considering the hose heat gain and static pressure loss.
 - 1.2.3.5.1. PCA units, while operating alone in the ADG IV mode, will be capable of cooling the aircraft cabin to 75°F for the largest ADG aircraft in the mix, listed in 1.2. Supply air will be at the aircraft connection with a single hose. Heating capacity will be a minimum of 115,000 British thermal units per hour (Btu/h) at 105 pounds per minute (lb/min) minimum.
 - 1.2.3.5.2. PCA units, while operating alone in ADG V mode, will be capable of cooling the aircraft cabin to 75°F within one hour for the largest aircraft in the mix listed in 1.2. at the aircraft connection with two supply hoses. Heating capacity will be a minimum of 260,000 Btu/h minimum.

1.3. Delivery, Storage, and Handling

- 1.3.1.** Lift and support PCA units with the manufacturer's designated lifting or supporting points.
- 1.3.2.** Disassemble and reassemble PCA units as required for movement into the final location following manufacturer's written instructions.
- 1.3.3.** Deliver PCA units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.
- 1.3.4.** Deliver and store flexible aircraft ducts (hose), aircraft adapter nozzles, baskets, and across-the-bridge devices to the jobsite in original, unopened containers with labels informing about manufacturer, product name, and other pertinent information.
- 1.3.5.** The shipment, unloading, and checking of equipment will be coordinated with the HAS Project Representative. Under no circumstances will the equipment be released for shipment or be delivered to jobsite without prior approval.
- 1.3.6.** The Contractor will examine all equipment and material delivered to the jobsite for concealed

damage and report any damage to HAS. The Contractor then will be responsible for loss or damage until project Substantial Completion.

- 1.3.7.** Protect all equipment and material during storage and prior to start-up which will include the coverings of all openings, protection against rust, and other damage. Equipment stored outdoors will be protected from weather.

1.4. Sequencing and Scheduling

- 1.4.1.** Coordinate with the boarding bridge manufacturer and installing contractor. Structural integrity and operational characteristics of the bridge will not be compromised. Submit evidence of coordination with the bridge manufacturer.

1.5. Extra Materials

- 1.5.1.** Furnish extra materials, described below, that match products installed, that are packaged with protective covering for storage, and are identified with labels describing the contents.
- 1.5.2. Filters:** Filters must be new, and one set will be required for each PCA unit.

1.6. Quality Assurance

- 1.6.1.** All equipment and material will be new, the latest design, and the first quality standard product of manufacturers regularly engaged in the production of such equipment and material.
- 1.6.2.** PCA units will be products of a single manufacturer.
- 1.6.3. PCA Unit Manufacturer's Qualifications:** Normally involved in the design and manufacture of specially constructed aircraft PCA equipment. Minimum five years' experience in producing the PCA units proposed.
- 1.6.4. Accessory Manufacturer's Qualifications:**
Firms regularly engaged in manufacturing of ductwork and equipment, of types and sizes required, whose products have been designed for industry use no less than two years. Ductwork and accessories must have demonstrated successful operation with the submitted and approved PCA unit.
- 1.6.5. Air Conditioning and Refrigeration Institute (ARI) Compliance:** Coils will comply with ARI 410; Air filter equipment will comply with ARI 850.
- 1.6.6. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Compliance:** Air filters will comply with ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates. Comply with ASHRAE and Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) recommendations pertaining to construction of ductwork.
- 1.6.7. National Fire Protection Association (NFPA) Compliance:** Comply with applicable portions of NFPA 70, for components and installation of PCA units.
- 1.6.8. National Electric Manufacturers Association (NEMA) Compliance:** Motors and electrical accessories will comply with NEMA standards.
- 1.6.9. Underwriters' Laboratories, Inc. (UL) Compliance:** Components will be certified by a nationally recognized testing laboratory for compliance with UL 1012. Provide documentation of certifications.
- 1.6.10. Turn-Key Operation:** The PBBs will be designed, manufactured, installed, tested, delivered and supported as a fully integrated unit, in compliance with the requirements defined in the project specification, Contract Drawings, addenda and attachments. The PBBs will incorporate the HAS

Standards for Passenger PCA, Ground Power, Potable Water and be installed as a “Turn-Key” assembly at the designated gate.

1.7. Shop Drawings and Submittals

1.7.1. Submittal data will include the following:

- 1.7.1.1. All technical data and calculations to support unit capabilities in order to provide cooling and heating performance at the specified design day conditions for each of the largest design.
- 1.7.1.2. **PCA Unit Data:** Include manufacturer’s technical product data, including rated capacities clearly indicated, dimensions, required clearances, weights, cooling and heating capacities, nominal compressor and heater capacities, furnished specialties and accessories, and installation and start-up instructions. Also include the following:
 - 1.7.1.2.1. Fan performance curves with system operating conditions indicated.
 - 1.7.1.2.2. Actual cubic feet per minute (CFM) at the minimum and maximum static pressure conditions for each selector switch position, and the input current (amps) at each condition. The CFM calculations must be completed and crosschecked both as per Aircraft requirements and applied ASHRAE standards.
 - 1.7.1.2.3. Motor ratings, electrical characteristics, motor and fan accessories. Blower motor manufacturer test results.
 - 1.7.1.2.4. Factory test reports for specified tests inclusive but not limited to Visual, Electrical, Functional, Performance and Final Adjustment. See section 3.2.1.
 - 1.7.1.2.5. Materials, gauges, and finishes.
 - 1.7.1.2.6. Method of capacity control for refrigeration (e.g., cylinder unloading, hot-gas bypass) and heating systems, defrost cycle, air volume control, and overload protection. Include the number of tubes and fin spacing for coil selection, refrigerant charge amount, and refrigerant volume including coils and piping. The units will be appropriately charged at the factory prior to testing of equipment.
- 1.7.1.3. **Accessory Product Data:** Submit manufacturer’s technical data for each type of ductwork, fitting, flexible connection, aircraft adaptor nozzle, and basket including dimensions, capacities, and materials of construction; and installation instructions.
- 1.7.1.4. Documentation of coordination with the bridge manufacturer indicating coordination efforts, including mounting requirements, loads, power, communication, control, interlock, precool control, and condensate coordination. PBB manufacturer will approve of PCA system connections drawings.
- 1.7.1.5. **Shop Drawings:** Detail equipment assemblies and indicate dimensions, weights, loading, required clearances, methods of field assembly, components, location, and size of each field connection. Also provide details on mounting and securing to PBB.
- 1.7.1.6. Wiring diagrams that detail wiring for power, signal, and control systems, while differentiating between portions of wiring that are factory-installed and portions to be field-installed.
- 1.7.1.7. **Operation and Maintenance (O&M) Manuals:** Submit maintenance data and parts list for each PCA unit, including a troubleshooting maintenance guide, servicing guide, preventive maintenance schedule, and procedures. Include in the O&M manuals directions for scheduled, routine air filter cleaning and/ or replacement. O&M manuals will contain the following information:
 - 1.7.1.7.1. Description and operation of all systems and components.
 - 1.7.1.7.2. Electrical drawings specific for each unit furnished. Provide two sets of bound, laminated electrical drawings for each unit, to be placed inside an access door to the unit controls.
 - 1.7.1.7.3. Maintenance instructions including troubleshooting/diagnostics guidelines.

- 1.7.1.7.4. Overhaul instructions.
- 1.7.1.7.5. List of parts and part numbers.
- 1.7.1.7.6. Illustrated list of all components.
- 1.7.1.7.7. Recommended spare parts list and sources.
- 1.7.1.7.8. Complete and detailed Preventive Maintenance Program for each type of PCA furnished under this Contract.

1.8. Warranty

1.8.1. Manufacturer will provide a two-year parts and labor warranty for the entire PCA system. A separate, minimum five-year factory warranty on the Programmable Logic Controllers (PLC), Direct Digital Controllers (DDC), Input/Output (I/O) Controllers, PCA unit compressors, motors, and coils is required. Warranty will commence with Substantial Completion of installation, after acceptance of equipment. Manufacturer agrees to replace, repair, or restore defective materials and workmanship of PCA unit work during warranty period. This warranty will be in addition to, and not a limitation of, other rights the Airport may have against the Manufacturer under the Contract Documents.

1.8.1.1. Defective is defined to include, but not be limited to, operation or control system failures, performances below required minimums, excessive wear, unusual deterioration or aging of materials or finishes, unsafe conditions, the need for excessive maintenance, abnormal noise or vibration, unexpected, and unsatisfactory conditions.

1.8.1.2. Warranty Claim Response Time: The manufacturer will ship repair parts and send a qualified service technician, if required, to HAS within 24 hours of being notified of an equipment failure while under warranty. Parts will be delivered to the appropriate HAS facility within 48 hours from the time the order was placed by HAS. If the manufacturer is unable to obtain the parts to restore the equipment to service, HAS reserves the right to obtain the replacement parts or service elsewhere and charge the total cost to the manufacturer, including labor and administrative fees.

Part 2 – Products

2.1. Manufacturers

2.1.1. Subject to compliance with requirements, provide products by one of the following, or as acceptable to HAS:

2.1.1.1. PCA units:

- Trielectron
- JBT Aerotech
- Twist Aero
- Or an approved equal

2.2. General Description

- 2.2.1.** Provide a PCA unit that can be mounted under the PBB, so that the operational characteristics of the bridge are unrestricted, and the bridge's structural integrity is uncompromised.
- 2.2.2.** The PCA unit at each gate will contain items listed but not limited to DDC communication devices, evaporator coils, evaporator blower, compressors, condenser coils, condenser fans, electric heating coils, refrigeration and temperature controls, motor controls, safety controls, air filters, smoke detector, complete motor starting equipment (including disconnect switch), condensate drain pan, and condensate discharge pump. These devices need to be included in order to provide the required cooling, heating, or ventilation air to meet the requirements specified.
- 2.2.3.** Centralized units must have integrated design to cool the Passenger Boarding as well. These Passenger Boarding Bridges should be designed with a custom fabricated ductwork system that fits the telescoping bridge so that there will not be a need for rooftop dx unit.
- 2.2.4.** The PCA unit(s) will have the capacity required to sufficiently cool the designated aircraft parked at a gate, considering quantity of air to be delivered and static pressures. Units will serve all aircraft listed for every unique gate, standardize unit capacity as much as practical to minimize inventory.
- 2.2.5.** The blower will be a centrifugal type and sized for the specified variable volume airflow requirements.
- 2.2.6.** Horsepower will be selected based on manufacturer's choice of equipment which affects the external resistance of the system. PCA unit manufacturer will furnish the blower motor, and unit size, adequate for final total pressure and maximum brake horsepower requirements.
- 2.2.7.** The unit will be constructed of a material that provides structural rigidity of frame and enclosure. It will also provide thermal insulation for conditions encountered in normal usage. Equipment exterior will be primed and painted to match bridge color and equipment interior finishes will be manufacturer's standard.
- 2.2.8.** The maximum sound level for the PCA units at maximum cooling will not exceed 85 decibels (A scale) (dBA) at a distance of 15 feet from the unit as measured using Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 1801 guidelines.
- 2.2.9. Casing:** Manufacturer's standard casing construction has a corrosion protection coating and exterior finish. Casings will have removable panels or access doors for inspection and access to internal parts, a minimum of 1-inch-thick manufacturer's standard thermal insulation, knockouts for electrical and exterior condensate drain connection, and lifting lugs. Insulation will meet requirements of NFPA 90A. All sheet metal parts will be prime coated prior to final assembly. Exterior casing surfaces will have a baked enamel finish coat after assembly. The color will match custom color selected for PBB. The following items will be fully removable and replaceable by removing access panels without removing the PCA unit from the bridge:
- Compressors
 - Blower/damper
 - Air filters
 - Coils
 - Controls
- 2.2.10.** Select mechanical equipment that uses only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.
- 2.2.11.** The unit must have capability to communicate with Gate Management System with seamless integration.

2.3. Temperature Control

- 2.3.1.** Factory-installed, demand-oriented control system, controls include temperature sensor which can be placed by gate agents in the aircraft interior.

2.4. Electrical Service

- 2.4.1.** Unit will require only a single feed 480/3/60 electrical connection. Provide transformers as required to feed components and controls utilizing other voltages. Where the unit requires electrical power greater than that indicated in the specifications and drawings, the Contractor will include the upgrade of the complete power system as required to each unit.

2.5. PCA Accessories

- 2.5.1.** PCA units will include the following accessories:

- 2.5.1.1. Control Panel:** Furnish panel for mounting on PCA unit which contains control of cooling and heating, evaporator fan, volume control, and indicator lights for unit functions. Panels will be located to allow access from PBB service ladder.
- 2.5.1.2.** Provide fire alarm system interface cable from the PCA, across the bridge, to the terminal. Also, provide communication system interface cable from the PCA across the bridge, to the Visual Docking Guidance System (VDGS). Coordinate with PBB manufacturer. PCA control panel will have an Auto-Off-Manual mode, will communicate aircraft type with the VDGS system, and set the units accordingly. While in the auto mode, the units will be able to define the aircraft type from the VDGS system and select the settings for that particular aircraft.
- 2.5.1.3. Gauge Ports:** Gauge ports will be required for refrigeration circuit. Pressure and temperature ports will be required on the PCA unit outlet plenum. All gauge ports will have caps secured by a chain.
- 2.5.1.4.** Outside air temperature sensor, manufacturer's standard intermediate and discharge temperature sensors, as required for system operation.
- 2.5.1.5.** The on-board temperature sensor assembly will be adaptable to a thermal resistor type aircraft sensor with 1,000 Ohm resistance of 70°F and a 3 Ohm per degree change. Temperature sensor will be provided with coiling cord of length to allow sensor to be placed inside aircraft cabin by airline personnel. Cord will be equipped with plug at end for connection to jack located in the boarding bridge cab.
- 2.5.1.6.** A condensate pump and drain pan will be provided for each PCA unit and will discharge to a condensate return line that runs across the PBB. The condensate pump will be lightweight, self-priming, and capable of running dry. Minimum pump rating will be 3 gpm, 40-foot head, and 1/3 hp. Position the drain pan under the coil section. The drain pan will be stainless steel with the capability of complete drainage leaving no standing water in pan.
- 2.5.1.7. Smoke Detector:** Furnish each PCA unit with a Siemens smoke detector downstream of the electric strip heat. Detector will be ionization type and listed by UL per UL 268A. The detector will operate at air velocities from 300 to 4,000 feet per minute. When smoke is sensed, the supply air blower will shut down. The detector will be of metal construction.
- Visual indication of alarm and pilot will be provided on the detector front and PCA unit exterior. A manual reset will be located on the front of the device. Detector heads will not require

additional filters or screens which must be maintained. The housing must contain a detector base which will accept ionization detector heads. Terminal connections will be the screw type. Terminals will be provided for remote pilot and alarm indication. Provide fire alarm system interface cable from the PCA, across the bridge, to the terminal. Coordinate with PBB manufacturer.

2.5.1.8. Unit Controller: A unit controller will be installed for each PCA unit. The controller will contain the required circuitry, power supplies, and other components necessary to perform the functional operation described below. It must be housed in a NEMA 4X enclosure. The controller enclosure will be located to allow access from the PBB service ladder. The PCA unit controller will have, as a minimum, the following functions and features:

2.5.1.8.1. Local and remote operator interface

with ground personnel will consist of the following:

- On/Off pushbutton station, lighted
- Stop Switch
- A380 selector switch as required for the mix of aircraft to be serviced at each gate; ADG IV or ADG V
- Summary fault indicator (overloads compressor circuits, filter alarm)

2.5.1.8.2. Monitor:

- Supply air dry bulb temperature
- Cabin dry bulb temperature
- PCA unit on/off
- PCA summary faults

2.5.1.8.3. Control:

- Air damper position.
- Refrigeration on/off/capacity level.
- Strip heat on/off/capacity level.
- Cabin temperature set point adjustment.

2.5.1.8.4. Gate Alarms:

- Smoke detector alarm/trouble.

2.5.2. Flexible Ductwork

2.5.2.1. Provide 14-inch-diameter, insulated, flexible duct (flat type) for extension of the ductwork from the unit mounted under the boarding bridge to the aircraft PCA connection at each gate. The hose will be provided in segments with a connecting device to allow easy replacement in the field without special tools. Each hose will be of a length required to serve the entire aircraft mix, but in no case requiring a taut over-extension to the connection point.

2.5.2.2. Provide 14-inch-diameter, insulated, flexible duct for extension of the ductwork from the unit to the PBB precooling/ preheating grille.

2.5.2.3. When the hose is supported by a hanger, the hanger will be a tube or elbow style design, and not a strap in order to prevent kinking the hose.

2.5.2.4. Maximum heat gain/loss, from leaving coil temperature to supply temperature, at the aircraft will be 7°F at design conditions.

2.5.3. Aircraft Adaptor Nozzle: Provide nylon, lightweight aircraft adapter nozzle(s) with integral handles for each hose at the gates as required to serve the entire aircraft mix. Provide a swivel joint at the hose to adaptor connection for ease of connection to aircraft.

- 2.5.4. Hose Basket:** A hose storage basket will be provided and installed, at the location shown on the drawings, at the end of each bridge and will be sufficient in size to easily store the required hose lengths. The basket will be constructed of steel frame with rounded top edges and corners, with sheet steel or expanded steel sides, and an open framework or expanded steel bottom. The top front edge, toward hose deployment direction, must have a minimum radius of 1 inch. A380 gates will be equipped with hose baskets adequately sized for storage of all hose assemblies required for service at those gates.
- 2.5.4.1. The hose basket will be mounted to the bridge support mechanism, as directed by the HAS Project Representative, accessible on the airside. Hose basket must be mounted, or otherwise positioned, so as to allow the boarding bridge to fully lower without damaging any piece of equipment.
- 2.5.4.2. Hose baskets connected to the apron drive bridges will be constructed such that they can be readily removed and reconnected.

Part 3 – Execution

3.1. Installation

- 3.1.1. PCA units will not transmit vibration to the passenger bridges. Manufacturer must provide vibration isolation.
- 3.1.2. Install units to provide access space around PCA units for service and maintenance.
- 3.1.3. Furnish all supports, brackets, guards, and safety hooks for installing PCA units on PBBs.
- 3.1.4. PCA units will be aligned, adjusted, and lubricated before final acceptance.
- 3.1.5. Perform air system testing and balancing.
- 3.1.6. Perform volume, pressure, and functional tests on each unit after installation on the PBB.
- 3.1.7. Prepare surface and spot paint all equipment where shop paint has been damaged or flaked off.
- 3.1.8. Paint to match existing color in accordance with equipment manufacturer's recommendations.
- 3.1.9. Apply color coded physical hazard stripe on PCA unit in accordance with manufacturer's suggested practice.

3.1.10. Connections

- 3.1.10.1. **Aircraft Connection:** Aircraft connections will be made with an aircraft adapter nozzle.
- 3.1.10.2. **Electrical:** Connect unit components to ground in accordance with the National Electrical Code (NEC).
- 3.1.10.3. **Condensate:** Condensate pump discharge will be delivered to the ramp near rotunda column by flexible condensate piping provided by Contractor. See Section 6 for plumbing standards.

3.2. Training

3.2.1. Factory Testing

- 3.2.1.1. Perform factory testing of volume, temperature, and pressure on each unit at design day conditions for each mode of operations prior to shipment to site.
- 3.2.1.2. **Submit Test Reports For Review:** PCA manufacturer will include pricing for factory witness testing of the submitted units. Witness test is to include travel and accommodations for two of the HAS representatives and one representative of the Designer's consultant.
- 3.2.1.3. Each unit will be factory tested to demonstrate scheduled capacity, and acoustic performance.
- 3.2.1.4. Testing will include three load points per PCA, which were submitted on the bid form for part load performance, in addition to the full load submitted performance. The ADG IV, ADG V, A380 load test points will consist of one point from each load value. The manufacturer will prove sustained stable unit operation with Houston Design Day conditions (96°F db, 80°F wb) proposed on the bid form, by way of a two-hour duration test. Manufacturers will not propose ambient values that cannot be proven during this sustained stable operation unit test. Alternately, the manufacturer can propose a test in an independent testing laboratory that can provide Houston Design Day conditions and complete the test.
- 3.2.1.5. The PCA unit test will be in accordance with SAE ARP 5374.
- 3.2.1.6. The units will not be accepted if the test results are above the acceptable limits. The manufacturer will make all necessary revisions and retest the equipment at no expense to HAS.

3.2.2. Examination

- 3.2.2.1. Examine areas and conditions, with the installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of PCA units.
- 3.2.2.2. Do not proceed until unsatisfactory conditions have been corrected.
- 3.2.2.3. Each PCA unit will be tested for a minimum of two hours in each mode of operation.

3.3. Quality Assurance

3.3.1. Quality Assurance

- 3.3.1.1. The following describes the minimum inspection and testing required in the Manufacturer's and Contractor's quality Control Program for the work of this Standard. The implementation of a Manufacturer and Contractor Quality Control Program does not relieve the Manufacturer and Contractor from the responsibility to provide work in accordance with the contract documents, applicable codes, regulations, and governing authorities. The Manufacturer's and Contractor's Quality Control Program will include, but not be limited to, the elements included herein. These elements are provided only as a minimum starting point for the Manufacturer and Contractor to generate the complete Manufacturer and Contractor's Quality Control Program.

3.3.2. Field Quality Control

- 3.3.2.1. **Manufacturer's Field Inspection:** The manufacturer will arrange an authorized on-site representative for the time required to assist and/or supervise the installation, start-up, and testing of all PCA gate equipment in accordance with the Manufacturer's written instructions. The on-site representative will be the point of contact for interface with the Manufacturer's home office engineering, manufacturing, and other support staff as needed. The on-site representative will also serve as liaison with the PBB manufacturer and HAS.
- 3.3.2.2. The service representative will be called to the site only after the installation is complete, and the HAS Project Representative has been notified at least five working days in advance.
- 3.3.2.3. Contractor will submit a written notice containing the test schedule, test procedure, and the personnel who will be present at the test.

3.3.3. Preliminary Procedures for PCA Unit Start-up and Testing:

3.3.3.1. Before operating the system, perform these steps:

- Check filters for cleanliness.
- Prepare report test sheets for each PCA unit and obtain the manufacturer's recommended procedures for testing.
- Lubricate all motors and bearings.
- Check fan rotation.
- Connect air handling unit, via flexible ductwork, to test section.

3.3.4. Start-up and Testing

3.3.4.1. PCA units will be tested for a minimum of two hours in each mode of operation. All will be witnessed by the HAS Project Representative.

3.3.4.2. Manufacturer will provide a field fabricated adjustable, test section, to simulate the pressure and flow restrictions of different aircraft.

3.3.4.2.1. The test section must be able to be attached to the 14-inch flexible PCA duct via an aircraft adapter nozzle.

3.3.4.2.2. The test section will be mounted on feet for stability, and a volume damper will be located at the far end of the test section to adjust static pressure and airflow. Also provide a port at the midpoint of the test section large enough to insert a pitot tube.

3.3.4.2.3. All PCA units will be tested during start-up in regard to airflow volumes, gauge pressure, and supply air temperature.

3.3.4.2.4. Conduct a functional performance test, witnessed by the HAS Project Representative, prior to acceptance of each gate's PCA equipment to ensure proper operation and function of the equipment. The HAS Representative will also check to ensure the equipment furnished is in accordance with the specifications provided. Perform all tests recommended by the Manufacturer and required by code. At a minimum, the following PCA unit operating functions are to be tested and recorded.

3.3.4.2.5. Aircraft Cooling Operation:

- Measure and record the supply air temperature, flow rate, and gauge pressure at the outlet of the aircraft connector.
- For gates servicing multiple sizes of aircraft, supply air recordings will be made for all selector switch options.

3.3.4.2.6. Aircraft Heating Operation:

- Measure and record the supply air temperature, flow rate, and gauge pressure at the outlet of the aircraft connector.
- For gates servicing multiple sizes of aircraft, supply air recordings will be made for all selector switch options.
- Verify electric strip heat stage control.

3.3.4.2.7. Bridge Precool and Preheat Operation:

- Measure supply airflow rate and temperature at the supply air grille.
- Verify correct damper position.
- Verify aircraft hose does not inflate when the PCA unit is in Bridge Precool/ Preheat operation, even if the hose is not properly stored in basket.

3.3.4.2.8. Safety Device:

- Perform a canned smoke test of the PCA unit smoke detector to verify proper unit shutdown and visual alarm indication.
- Verify unit restarts after manual reset energized.

3.3.4.2.9. Record and Report Data:

- Record all data obtained during start-up and testing procedures as approved on the sample report forms.
 - Provide back-up calculations that verify the recorded values match expected unit operation at the outdoor conditions the tests were run at.
 - Provide recommendations for correcting unsatisfactory mechanical performances when system does not meet specified design criteria.
 - Correct all deficiencies resulting from tests.
- 3.3.4.2.10. In the event that equipment defects necessitate the rejection of the PCA equipment, the HAS Project Representative will have the right to operate the equipment without additional cost until such time as new equipment is provided to replace the rejected equipment. Replacement of the equipment will be coordinated and scheduled with HAS.

3.3.5. Training

3.3.5.1. Review the information contained in the O&M data with HAS personnel.

3.3.5.2. Schedule training, giving HAS at least seven days prior notice.

3.3.5.3. The scheduled training will include a minimum of 40 total hours of training administered as follows:

3.3.5.3.1. Training may include up to 12 personnel over two shifts.

3.3.5.3.2. Training will include start-up, shutdown, servicing, preventive maintenance, and troubleshooting. Information will also be provided concerning procedures for obtaining repair parts and technical assistance.

3.3.5.3.3. Review O&M manuals during training sessions.

3.3.6. Adjusting, Cleaning, and Protecting

3.3.6.1. The Contractor will clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels and cabinets.

3.3.6.2. The Contractor will clean or replace air filters.

3.3.6.3. The Contractor will clean and comb evaporator and condenser coil fins.

37- SANITARY SEWER



37 - Sanitary Sewer

Part 1 – General

1.1. Overall

- 1.1.1. The intent of the Houston Airport System (HAS) sanitary sewer design criteria is to establish a baseline set of criteria for exterior Sanitary Sewer Systems (SSS) anywhere in the HAS system that coordinate and augment the criteria used by the City of Houston (COH).
- 1.1.2. The Designer's Engineer-of-Record (EOR) must consult the most recent edition of the respective COH Infrastructure Design Manual (IDM), as criteria for specific projects prior to commencing design. Coordinate any discrepancies between this Standard and the criteria with the HAS Project Manager. The EOR must obtain written verification of the criteria to be applied to each project prior to commencing design.
- 1.1.3. Existing utility information is available through the various HAS departments. The most current as-built information is available from the Infrastructure Division; however, it will be expressly understood that HAS cannot accept responsibility for the locations shown on "as-built" drawings. It will be the EOR's responsibility to verify locations, or the adequacy of file information, prior to design and construction of utility extensions, duct banks, conduits, or connections to such facilities.
- 1.1.4. All proposed connections to the SSS will be described by drawings and specifications from the user or facility side of the lateral to actual connection to the Airport main(s).
- 1.1.5. Except as specifically allowed in writing by HAS, no off-site or off-system sanitary sewer is allowed into any facility owned sanitary, operated or maintained by HAS.

1.2. Quality Assurance

- 1.2.1. All design criteria in this section will be reviewed by the EOR in charge of the design for applicability, validity, and usage on the project. The EOR will alert HAS as to any conflicts that arise between these criteria and engineering judgment in the context of the project design. The conflicts will be reviewed with HAS and resolved in writing prior to issuance of the construction documents. HAS will not be responsible for any fees that arise related to unresolved conflicts between the criteria and the engineer's judgment. HAS's agreement with the EOR's judgment does not relieve the EOR of responsibility for the design.

1.3. Shop Drawings and Submittals

- 1.3.1. Submit shop drawings for all products required to complete the work.

1.4. Warranty

- 1.4.1. All products and/or workmanship will be warranted for at least one year after the date accepted by HAS and the COH.

Part 2 – Products

2.1. Information

- 2.1.1.** It is highly recommended that a cementitious fill material be considered as backfill for all trenches occurring under any roadway, runway, taxiway, shoulders, or parking lot. Good engineering practice, scheduling, construction demands (material set time), and any future excavation requirement will be considered in selecting the proper material. All pipes under any roadways, runways/taxiways safety zones, shoulders, or parking lots will be placed using Class A bedding.
- 2.1.2.** Wherever possible, disposal of sewage will be by gravity to the SSS. Airport mains will be extended as required to establish gravity flow disposal. Ejector type pumps will only be allowed when gravity connection to the SSS is not possible. On-site disposal will only be allowed in remote Airport areas where mains do not exist or cannot be extended for gravity or ejector disposal.
- 2.1.3.** Wastewater mains will have slopes that allow the flows to achieve velocities of 3.0 feet per second (ft/sec), if possible. The minimum velocity will not fall below 2.0 ft/sec. Pump stations will be employed should slopes not achieve a velocity of 2.0 ft/sec. Slopes that will create a flow velocity in excess of 10.0 ft/ sec. will be avoided.
- 2.1.4.** Manholes will be cast-in-place reinforced concrete and installed every 300 feet, at connections to mains, and at 45 and 90-degree changes in main runs. Manhole covers will have “Sanitary Sewer” imprinted on them. Aircraft rated manholes and covers are required within all runway and taxiway safety areas.
- 2.1.5.** Approved materials for gravity flow sanitary sewer pipe are:
- American Society for Testing and Materials (ASTM) D2241 SDR 26
 - American Water Works Association (AWWA) C900
 - C905 Polyvinyl Chloride (PVC) pipe,
 - ASTM D 2680 PVC pipe
- 2.1.5.1.** SDR-35 PVC will not be used.
- 2.1.5.2.** Elastomeric gaskets will also meet ASTM F477.
- 2.1.5.3.** The minimum lateral size will be 6 inches in diameter.
- 2.1.5.4.** All lateral to main connections will be made at a manhole.
- 2.1.6.** AWWA C900, C905, or C303 reinforced concrete cylinder pipe (RCCP) is required for all pressurized applications.
- 2.1.6.1.** ASTM D 2680 PVC pipe will not be used for pressurized mains.
- 2.1.6.2.** All pressurized pipe will be installed within casings under roadways, taxiways, and runways. Casing pipe will be RCCP or PVC (Schedule 80 or AWWA C900). Steel casings can be used with proper cathodic protection.
- 2.1.6.3.** All pipe installed within sleeve will require spacers on 4-foot center.
- 2.1.6.4.** Corrugated steel pipe will not be used as casing pipe.
- 2.1.7.** Longitudinal deflection at each pipe joint will not exceed one degree in any direction.
- 2.1.8.** Lift stations will include a minimum of two submersible electrically operated sewage pumps (redundant) with low level shutoff, high level alarm, and intermediate level sensors required for pump cycling. Ultrasonic sensor technology will be considered for level measurements. Pumps will be manufactured to grind and safely pump wastewater.

- 2.1.8.1. Wet-pits will be concrete, cast-in-place with access for inspection and pump maintenance.
- 2.1.8.2. Lift stations will be located with consideration for screening, maintenance access, and emergency access.
- 2.1.8.3. **Bedding and Backfill:** After trench has been cut to a depth below the barrel of the pipe, a distance of 3 inches, the bedding will be brought to a point 1/8 pipe diameter above grade with cement stabilized sand. Bell holes will be formed, if required, a trough scooped out to grade and the pipe laid and jointed as specified. The cement stabilized sand will then be brought up in uniform layers on either side of the pipe and over the pipe to a point 6 inches above the top and 6 inches below bottom of the pipe. Density will be at least 90 percent of maximum density as determined by ASTM D 698. Moisture content will be within minus two to plus four of optimum.
- 2.1.8.4. Part 3 – Execution

3.1. Installation

- 3.1.1. Follow industry common best practices.

3.2. Training

- 3.2.1. Prior to testing, all sanitary sewer lines must be inspected with a video system and a copy of the DVD submitted to the HAS Project Manager for approval. After approval of the DVD, all installed SSS pipe must be tested. The completed system will have a zero-exfiltration loss per two hours, where the hydrostatic head at the design hydraulic grade line is no less than 4 feet of test stack with the height of the test stack matching the highest elevation of the SSS. A pneumatic test at 3 pounds per square inch (psi) may be substituted for the hydrostatic test to substantiate the exfiltration criteria. The air pressure will be equivalent to the comparable hydrostatic test pressures. Certified copies of all tests will be provided to the HAS Project Manager.
- 3.2.2. Manholes must be vacuum-tested with a negative pressure of 3 psi, maintaining a zero pressure drop for five minutes.

38- LANDSIDE CIVIL DESIGN



38 - Landside Civil Design

Part 1 – General

1.1. Overall

- 1.1.1. **General Information:** For all non-airfield roadway projects within the Houston Airport System (HAS) campuses, the latest edition of the *Texas Department of Transportation (TxDOT) Highway Design Section Operations and Procedures Manual* and the *City of Houston Infrastructure Design Manual* that contains the basic design criteria will be followed. Deviation from these criteria will not be allowed without written approval from the City Engineer.
- 1.1.2. Construction specifications will be taken from the latest edition of the *Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic* published by the City of Houston (COH) Houston Public Works Department (HPW), except as modified herein. No variance from these specifications may be made without the approval of the City Engineer.

1.2. General Criteria

- 1.2.1. **Design Criteria:** The following minimum criteria apply to all non-airfield roadways within the HAS Airport Campuses. Deviations from these requirements require approval from the City Engineer.

1.2.2. Rights-of-Way (ROW)

Classification	Roadway ROW Width
Freeway	400 Feet
Primary Arterial	150 Feet
Secondary Arterial	120 Feet
Local Road	80 Feet

1.3. Design Speeds

- 1.3.1. The design speed represents the maximum safe speed that can be maintained over a section of roadway and is influenced by the required posted speed limit, terrain, functional road classification, and economic considerations. All design criteria will be commensurate with selected design speeds. All selected design speeds will be presented to the HAS Project Manager for review and approval prior to final design.
 - 1.3.1.1. **Freeway:** Currently, JFK Boulevard and Will Clayton are the only designated major arterials at George Bush Intercontinental Airport (IAH). The posted speed limit on both JFK Boulevard and Will Clayton is 50 miles per hour (mph) except where the speed limit is reduced for safety reasons. The posted speed limit on the various City roadways is regulated by the COH PWE and may be subject to change.
 - 1.3.1.2. **Primary Arterial System:** The JFK frontage roads are considered a primary arterial and are currently posted at 45 mph throughout.

- 1.3.1.3. **Secondary Arterial System:** Through routes linking major roadways and providing access to major facilities are currently posted at 30 to 35 mph.
- 1.3.1.4. **Collector System:** The posted speed limit for the terminal roadways will be 30 mph.
- 1.3.1.5. **Local Road System:** This type of local access road provides a direct access to abutting property (e.g., parking lots, terminals, lease sites) for local traffic circulation movements and will have posted speed limits of 30 mph.
- 1.3.1.6. **Ramps:** The design speed for on-and-off ramps will be determined in accordance with TxDOT criteria. Under conditions of restricted geometrics on certain ramp connections, the design speed will not be less than 25 mph.

1.4. Design Vehicles

1.4.1. Size and Weight

- 1.4.1.1. The physical and operating characteristics of an authorized vehicle of designated type establishes roadway design controls to accommodate the vehicle of that type. All new and major reconstruction of roadways will be designed to meet minimum requirements set forth for WB-50 design vehicles, unless waived by the City Engineer, in which case the design vehicle will be a single-unit (SU) truck as an absolute minimum. TxDOT has established minimum turning paths for these design vehicles to be used as controls in geometric design. It is vitally important that standard fire-fighting, ARFF and other emergency equipment can maneuver on all airport circulation roads, even those outside the AOA.
- 1.4.1.2. Load limits will conform to the minimum requirements set forth for Federal and State highways.

- 1.4.2. **Turning Radii:** All turning radii will be designed to accommodate the wheel path of the critical design vehicles without encroachment of curbs. The minimum design radius at intersections is 30 feet, and the minimum design radius at driveways will be 15 feet.

1.5. Alignment

- 1.5.1. **Stopping Sight Distance:** Safe stopping sight distance will be established using wet pavement conditions and, as the controlling design vehicle, the passenger car with eye height at 3.5 feet and object height of 0.5 feet. Design values will be in accordance with the requirements listed in the TxDOT Manual.
- 1.5.2. **Horizontal Curvature:** The maximum degree of curvature will conform to the design values listed in the TxDOT Manual for a particular design speed.
- 1.5.3. **Super Elevation:** The maximum rate of super elevation is 0.06 feet per foot.
- 1.5.4. **Vertical Curvature:** Length of vertical curves is determined by the algebraic sum of gradients and the design speed. The K-values listed in the TxDOT Manual for crest curves and sag curves will be used in calculating the minimum required lengths of vertical curves.
- 1.5.5. **Ramp Geometry:** All on-and-off ramps, and direct connections to arterials, will be designed for a minimum of one lane of traffic operation with provisions for emergency parking unless otherwise directed.
- 1.5.6. **Maximum Grades:** The maximum grade of ramps is 6 percent.
- 1.5.7. **Minimum Grades:** The minimum grade of ramps is 0.5 percent.

1.6. Cross Section Elements

- 1.6.1. **Pavement Width:** The minimum standard lane width of 12 feet will apply to all roadway systems under this section, including Aircraft Rescue and Firefighting (ARFF) roads except ramps where a minimum standard lane width of 14 feet will be used. Bi-directional two-lane roads, without usable shoulders,

require a total pavement width of no less than 34 feet except for perimeter roads within the Air Operations Area (AOA) where the total pavement width may be 24 feet.

- 1.6.2. Shoulders:** On major, high design speed (equal to or greater than 50 mph), uncurbed facilities, a minimum traversable shoulder width of 10 feet is required.
- 1.6.3.** On one-lane ramps, shoulders will be placed on each side of the travel lane for a combined effective width to allow a stalled or stopped vehicle to be passed. Outside shoulders will be a minimum of 6 feet and inside shoulders a minimum of 2 feet.
- 1.6.4.** Six-inch curbs will be used primarily on collector, service roads, and other low speed (less than 50 mph) type facilities. They will not be used in connection with high speed facilities, expressways, and ramp areas. Where needed for drainage purposes at ramps, curbs will be mountable type. On two-lane, two-way roads, a minimum of 2 feet on each side for curb and gutter will be included in the total width of the roadway.
- 1.6.5. Speed Change Lanes:** This applies to auxiliary lanes with respect to median openings and at-grade intersections supplementary to through traffic movements. The required length of the auxiliary lanes and size of median opening for turning vehicles will be in accordance with applicable standards as outlined in the TxDOT Manual.
- 1.6.6. Cross Slope:** The standard cross slope on all new paving projects and major reconstruction paving projects is ¼ inch per foot of pavement width.
- 1.6.7. Special Features:** It is recognized that certain conditions will require the use of features not described in this Standard. The design of these features will be based on good engineering practice for the specific feature and based on similar designs used by the COH. The design will consider the functional characteristics of the installation as well as the familiarity of the driver with the installation.
- 1.6.8. Roadway Signs and Markings:** The design of signs and markings for roadways will be in accordance with the latest version of the *Texas Manual for Uniform Traffic Control Devices*. The signs, posts, breakaway features, and foundations will conform to TxDOT Standards. The erection of signs on bridge structures will require prior written approval from the HAS Project Manager.

1.7. Shop Drawings and Submittals

- 1.7.1.** All non-airfield roadway construction contract documents within the HAS Airport Campuses will be prepared in accordance with Section 1.1 of this Standard.

Part 2 – Products

2.1. Earthwork

- 2.1.1. Soil Investigations:** A review of existing soils information will be performed to initiate any field investigations. The existing information will be used to develop a general soils profile for a preliminary geotechnical analysis. The subsurface investigation will consist of an adequate number of soil borings. Boring locations will be selected based on the specific plans for the proposed excavation, accessibility of the drilling equipment, and information obtained during the review of the existing soils information.
- 2.1.2. Subgrade, Soils, and Pavement Testing Investigation Program:** The project Designer will prepare a recommended soils program for the HAS Project Manager's review and acceptance. A final soils report will be submitted with the final construction documents and included as an Appendix to the Project Design Report.
- 2.1.3. Subgrade Treatment:** All subgrades will be either lime/fly ash-treated or cement/ fly ash-treated depending on whether the underlying soil is sand or clay. The thickness of the treated subgrade and

quantity of lime, cement, and fly ash will be specified in the construction documents submitted by the Designer. Placement of the lime/flyash or cement/flyash should be in slurry form.

2.2. Flexible and Rigid Pavement

- 2.2.1. Street Pavement Design Section:** Pavement structure, including thickness, reinforcing, base and subgrade stabilization shall be designed by a Licensed Professional Engineer based on the extended roadway use for a minimum 50-year life span. The minimum roadway pavement section shall be 9-inch-thick, continuously reinforced, concrete pavement, 5 inches of cement treated base (alternate as 5 inches of asphalt base), and 9 inches of lime/fly ash or cement/fly ash treated subgrade, depending on whether the soils are sandy or clay. Refer to the City of Houston Infrastructure Design Manual for more information. Placement of the lime, cement, lime/flyash or cement/flyash should be in slurry form. All curbs will be poured monolithically with the roadway pavement following TxDOT design standards. Types of expansion joints should be reviewed and selected for approval during design phase. Flexible pavement designs will only be accepted on a case-by-case basis as approved by the HAS Project Manager.
- 2.2.2. Sidewalks:** Pedestrian walks shall be Portland cement concrete and constructed between buildings and other essential locations where such a need may occur. The minimum standard width for sidewalk pavement will be 4 feet with proper cross slope for adequate drainage. The minimum standard walkway pavement will be 4-inch-thick concrete reinforced with flat 6-inch by 6-inch, W2.9 by W2.9, welded wire fabric on a minimum 2-inch sand cushion. Rolled wire fabric will not be permissible as walkway or other reinforcing. Provide contraction joints spaced every 4 feet (approximate). Pre-molded ½ inch expansion joint material spaced at 32 feet is required. Sidewalks, curb cuts and ramps shall meet the accessibility requirements of the Americans with Disabilities Act and TDLR.

2.3. Storm Drainage

- 2.3.1.** Refer to the Storm Drainage Standards for more information.

2.4. Structures

- 2.4.1.** Design for all bridges, tunnels, retaining walls, culverts, vaults, and all other structures supporting vehicles and earth/ water will be in accordance with the requirements listed in the TxDOT Manual, latest edition.
- 2.4.2.** Protective devices such as concrete barriers, guardrails, crash cushions/ impact attenuators, etc. will be designed in accordance with the TxDOT Highway Manual, latest edition.
- 2.4.3.**

Part 3 - Execution (Not Used)

39- BUILDING ENVELOPE



39 - Building Envelope

Part 1 – General

1.1. Overall

1.1.1. This Standard provides both general and prescriptive directions relative to the performance of critical building components including but not limited to building shell, exterior enclosure, roofing and interiors.

Part 2 – Products

2.1. Thermal Performance

2.1.1. Construction will minimize energy consumption and provide thermal resistance as necessary to maintain interior comfort levels specified in accordance with applicable codes and the following:

2.1.1.1. Average Thermal Transmittance: Maximum U-value will be as per 2015 International Energy Conservation Code (IECC) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1-2013.

2.1.1.2. Condensation: Very limited condensation on interior surfaces, under normal interior temperature and relative humidity conditions, during 98 percent of the days in the coldest three months of the year.

2.1.1.3. Components that Have Surfaces Facing Both Interior and Exterior Environment: Condensation resistance factor (CRF) as required to meet the requirement above, when tested in accordance with the latest edition of American Architectural Manufacturer's Association (AAMA) 1503.

2.1.2. Air Infiltration: Maximum of 0.06 cubic feet per minute (cfm) per square foot of exterior surface area, measured in accordance with the American Society for Testing and Materials (ASTM) E 283-2004 at different pressure of 6.24 pounds per square foot (psf).

2.1.2.1. Use supplementary air barrier if necessary, to maintain performance over the entire shell.

2.1.2.2. Use methods of sealing joints between elements that will be effective given available construction practices.

2.2. Glazing

2.2.1. Natural Light: Provide fenestration in shell as needed to meet requirements for natural light in accordance with code and the following:

2.2.1.1. Exterior Glazing: Design fenestration to maximize daylighting and energy savings without creating glare, using glass curtainwalls, punched windows, and clerestory and skylights. Use of skylights will be limited to major public spaces and when used will be accessible for cleaning.

2.2.1.2. Glare Mitigation, Interior: Design fenestration to control glare within terminal facilities for gate podiums, flight information display system (FIDS), gate information display system (GIDS), and advertising display monitors. These and other displays will remain legible under natural light conditions at any time during the day, the majority of the year.

2.2.1.3. Glare Mitigation, Exterior: Design building enclosures such that the reflection from fenestration or other reflective materials, do not interfere with the operation of any ramp control towers (as applicable to the project).

2.3. Acoustical Performance

2.3.1. Design and construct the shell to limit sound transmission into terminal facilities as follows:

2.3.1.1. Ambient Sound Level: Maintain ambient sound levels in perimeter spaces within Noise Criteria (NC) ranges, including jet noise from aircrafts.

2.3.1.2. Vibration Control: Use shell elements that will not resonate at frequencies that are characteristic of ambient exterior sound sources at the project site. Use material and construction methods that will avoid vibrations of floors or ceilings caused by baggage conveyor belts.

2.4. Exterior Surfaces

2.4.1. Cleanliness of Exterior Surfaces: Design the exterior shell and select materials to:

2.4.1.1. Minimize attraction and adherence of dust and air-borne dirt and soot from aircraft engine emissions and minimize appearance of settled dust and dirt.

2.4.1.2. Avoid rainwater run-offs from roof and parapets along exterior vertical or sloped surfaces.

2.4.1.3. Avoid run-off from washing settled dust and dirt over surfaces exposed to the view of the traveling public.

2.4.2. Appearance: Design exterior shell and select materials as follows:

2.4.2.1. Conceal mechanical equipment, plumbing equipment, electrical equipment, piping, conduit, and ductwork from view from roadways as much as possible.

2.4.2.2. Conceal rooftop mechanical equipment, plumbing equipment, electrical equipment, piping, conduit, and ducts from view.

2.4.3. Water Penetration: The construction will prevent water penetration into the interior of shell assemblies, under conditions of rain driven by a minimum 130 mph wind.

2.4.3.1. Building envelope system will be a barrier system, not allowing water penetration.

2.4.4. Weather Resistance: Design and select materials to minimize deterioration due to precipitation, sunlight, ozone, normal temperature changes, salt air, and atmospheric pollutants.

2.4.4.1. Deterioration includes corrosion, shrinking, cracking, spalling, delamination, abnormal oxidation, decay, and rot.

2.4.4.2. Surfaces Exposed to View: Deterioration adversely affecting aesthetic life span includes color fading, crazing, and delamination of applied coatings.

2.4.4.3. Joint Components and Penetration Seals: Capable of resisting expected thermal expansion and contraction, use overlapping joints that shed water wherever possible.

2.4.4.4. Transparent Elements (Glazing): No haze, loss of light transmission or color change during entire expected service life.

2.4.4.4.1. Test Criteria: Less than 1 percent change in haze, transmission, and color over two years of exposure. When tested after natural exposure conditions or accelerated light and water conditions, simulating natural exposure at project, in accordance with ASTM D 1003-2000; accelerated exposure documented with comparison to natural conditions.

2.4.4.5. Service Temperature: Low temperature equal to historically recorded low; high temperature, equal to that expected, due to any combination of air temperature and heat gain from solar and other sources.

2.4.4.6. Corrosion Resistance: In locations exposed to the outdoor air, or in potential contact with moisture inside shell assemblies, the construction will use only corrosion-resistant metals.

2.4.4.7. Ozone Resistance: Do not use materials that are adversely affected by ozone.

2.4.5. Impact Resistance: Design and select materials to resist damage due to impact in accordance with applicable codes and the following:

2.4.5.1. The construction will minimize damage from windborne debris propelled at a minimum of 130 mph.

2.4.5.2. Materials will be designed and selected to resist damage from hail of size up to ½ inch.

2.4.6. Moisture Vapor Transmission: Design to prevent deterioration of materials due to condensation of moisture vapor inside assemblies.

2.4.6.1. Use supplementary vapor retarder if necessary to meet requirements.

2.4.6.2. Use method of sealing joints between elements that will be effective given available construction practices.

2.4.7. Wear Resistance: Design and select materials to provide resistance to normal wear-and-tear in accordance with code and the following:

2.4.7.1. **Elements Within Reach of Pedestrians:** Minimize degradation from rubbing and scratching caused by pedestrians.

2.5. Service Life

2.5.1. Curtain Wall Assembly (excluding sealant) – 50 years

2.5.2. Metal Panel Assembly (excluding sealant) – 30 years

2.5.3. Cementitious Plaster Wall Assembly (excluding sealant) – 30 years

2.6. Thermal Transmittance

2.6.1. Design building exterior enclosures to protect the interior from exterior temperatures, sun radiation, wind and water, whether it is normal, or wind driven rain or window washing water.

2.6.1.1. Average thermal transmittance minimum U-value over the entire exterior enclosure elements, other than vision glass, will be as specified by the Energy Code and ASHRAE 90.1.

2.7. Water Penetration

2.5.4. Mock-up Test is Required: Static pressure test in accordance with ASTM E 331-2000. ASTM E 1233 for cyclic testing.

2.5.5. Field dynamic water test for curtainwall systems is required as per AAMA 502 Infiltration.

2.5.6. Where interior skin is not an integral part of exterior enclosure, test without interior skin installed.

2.7.1. Flashing: Federal Emergency Management Agency (FEMA) P499 for roof to wall and floor to wall.

2.7.2. Infiltration: AAMA 502 and ASTM E1105 recommended test method.

2.7.3. Missile Impact Testing: ASTM E1105

2.8. Airborne Sound Isolation

2.8.1. Terminal facility concourses: they contain large public spaces that will be subject to noise build up due to high-capacity pedestrian activities, as well as intrusion from aircraft operations. Overall acoustical design goals are to assure comfort of the occupants, ease of face to face communications, and intelligibility of the public address system. The Designer will develop overall acoustical criteria in five categories as follows:

2.8.1.1. **Annoyance Factor Due to Continuous Background Noise:** Maximum NC ratings will be:

- Retail: NC-40
- Offices: NC-35 to 40
- Club Lounges: NC-30 to 35

2.8.1.2. **Annoyance Factor Due to Short-Term Noise Intrusion:** Short term noise intrusion will occur as a result of aircraft operations. Maximum allowable short term noise intrusion will not exceed:

- Holdrooms: 60-65 decibels (A scale) (dBA)

- Concourse: 60-65 dBA
- Other spaces: 65-70 dBA

2.8.1.3. Speech Interference: Speech interference levels will not exceed the following levels:

- Holdrooms: SIL 50-55 dB
- Concourse Area: SIL 50-55 dB
- Other Spaces: SIL 55-60 dB

2.8.1.4. Interior Acoustic Separation of Spaces: Minimum criteria for acoustic separation of occupied spaces:

- Airport Operations: STC-45 NIC-40
- Retail: STC-45 NIC-40
- Food and Beverage: STC-45 NIC-40
- Offices: STC-45 NIC-40
- Restrooms: STC-50 NIC-45
- Club Lounges: STC-55 NIC-50
- Mechanical Rooms: STC-55 NIC-50

**STC - Sound Transmission Control; NIC - Noise Isolation Class*

2.8.1.5. The Designer will achieve the following minimum Outdoor-Indoor Transmission Class (OITC) level reduction values

- 2.8.1.5.1. Moderately noisy space, i.e., office type space and very loud exterior noise source (dBA 70-80): OITC 32/STC-41
- 2.8.1.5.2. Moderately noisy space, i.e., public space and very loud exterior noise source (dBA 70-80): OITC 29/STC-35

2.8.1.6. Design Substantiation: The Designer will substantiate acoustical performance of the exterior enclosure at the following design milestones:

- 2.8.1.6.1. **30 percent Schematic Design Completion:** Calculated OITC values of building enclosures and interior NC values.
- 2.8.1.6.2. **At Substantial Completion:** Actual noise measurements.

2.8.2. Glazing: Unless higher performance is required by envelope calculations provide, at a minimum, insulated units consisting of (from outside to inside) ¼-inch glass, ½ inches of air space and two layers of 3/16-inch laminated glass. To reduce glare at high curtainwall systems, use different type of glass tints or fritting lighter at the bottom to darker at the top, as recommended by the Designer.

Part 3 – Execution

3.1. Testing

3.1.1. Provide design calculations and testing laboratory reports on the façade system for sound transmission, thermal performance, glare reduction, impact resistance and water tightness.

3.2. Maintenance

- 3.2.1.** Design must accommodate equipment for complete window washing, including equipment, and utilities for maintenance of all exterior enclosure surfaces including glazed and metal panel areas. Provide for storage or window washing equipment including platforms and mechanized lifts.
- 3.2.2.** Design and plan for storage spaces/rooms for maintenance equipment including lifts, platforms, cherry pickers, etc.

40- EXTERIOR IMPROVEMENTS



40 - Exterior Improvements

Part 1 – General

1.1. Overall

- 1.1.1.** This Standard is primarily concerned with project elements outside of buildings and structures. Typical project elements included herein are those that extend outside of the building starting at the Civil interface, or as specifically defined for each project element. The elements in this zone are determined by other Standards in this manual and must be consulted. Many Houston Airport System (HAS) civil projects and/or project components may also require the appropriate application of a combination of design standards/criteria originating from different sources/agencies. This is especially true when a project crosses the Air Operations Area (AOA) boundary and/or extends outside the airport property. The appropriate source to use by the Designer or Contractor depends on project-specific aspects that may include location, discipline, funding source, and interfaces with other projects. The primary sources for design criteria may be HAS, the Federal Aviation Administration (FAA), the City of Houston (COH), the Harris County Flood Control District (HCFCD), or other sources. The Designer/Contractor will employ the design standards as appropriate to the project requirements, except where superseded herein by this Standard.
- 1.1.2.** The design standards detailed herein are considered minimum standards and are subject to the judgment of the licensed Professional Engineers, Architects, and/or Land Surveyors with responsible charge of their design elements. Where discrepancies arise during project development, the Designer/Contractor will make recommendations, in writing, to the HAS Project Manager for the appropriate design standards to be used on the project prior to commencing design and receive written approval from the HAS Project Manager.
- 1.1.3.** Civil landside projects, or project components, typically include all areas located outside the AOA. The interface between design standards used on project components is a critical issue that must be clarified early in design to avoid negatively affecting projects. In the case of a discrepancy or difference between the individual design criteria, the most conservative or strict requirements will govern, except as approved by the HAS Project Manager.
- 1.1.4.** Use of the FAA Advisory Circulars (AC) are mandatory for all projects funded by federal grant monies through the Airport Improvement Program and/or with revenue from the Passenger Facility Charges (PFC) Program. This is to ensure certification of the HAS Airports as part of Title 14 Code of Federal Regulations (CFR) Part 139, Certification of Airports, subparts C (Airport Certification Manual) and D (Operations). Although the FAA ACs are not mandatory for non-FAA funded or non-PFC funded projects, the Designer will follow the minimum requirements put forth in the ACs for all work within the AOA to ensure compliance with the Part 139 requirements. Where the FAA AC's do not provide direction for project components, the Designer will coordinate with the HAS Project Manager to verify the appropriate standards to use. The Designer will attain approval of the approved design standards in writing from the HAS Project Manager before commencing design. Any fees related to design changes resulting from using non-approved design standards will be borne by the Designer, or as specified in the Designer's contract.
- 1.1.5.** FAA Standards may be obtained from the:
- Federal Aviation Administration, Post Office Box 1689, Fort Worth, Texas 76101;

- U. S. Department of Transportation, Subsequent Distribution Section, M-4943, Washington, D.C. 20590;
 - Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402;
 - Or other FAA regional offices. Most FAA standards and forms are available through the FAA website.
- 1.1.6.** In some instances, portions of a project or a project component may not fall under the scope of the FAA AC's, even though it may reside inside the AOA. For instance, public waterlines and wastewater lines may be part of an Airside project for which the FAA may have no AC covering the design and construction or relocation of the utility, except as provided for in the crossing of aircraft-loaded pavements. In these instances, the Designer will recommend the appropriate design standard and/or specification to the HAS Project Manager. The Designer will receive written approval from the HAS Project Manager prior to commencement of design. Since all the HAS Airports reside in the COH and/ or Harris County, the appropriate design standards and specifications that will serve in-lieu of FAA standards are provided by the COH and Harris County/HCFCD. Refer to the Landside Civil and other infrastructure- related Standards for more information.
- 1.1.7. Survey Standards:** The Surveyor of Record for the project/study being designed/conducted and/or constructed will provide professional surveying services according to all applicable laws, codes and standards of the industry, and pursuant to the requirements of their licensure. All survey work on HAS airports is subject to the requirements set forth by the FAA. The Surveyor will perform all work according to the most recent edition of:
- 1.1.7.1. FAA Advisory Circular AC 150/5300- 18:** General Guidance and Specifications for Submission of Aeronautical Surveys to National Geodetic Survey (NGS): Field Data Collection and Geographic Information System (GIS) Standards;
 - 1.1.7.2.** HAS Surveyors Handbook specifically written for each airport (George Bush Intercontinental Airport [IAH], William P. Hobby Airport [HOU], or Ellington Airport [EFD]) at which the project is located. The HAS Surveyor Handbooks are provided by HAS prior to commencing survey work and are published online.
- 1.1.8. Some other applicable referenced FAA AC's may include:** AC 150/5300- 17 - Standards for Using Remote Sensing Technologies in Airport Surveys, AC 150/5300-18, and AC 150/5300-16 - General Guidance and Specifications for Aeronautical Surveys, Establishment of Geodetic Control, and Submission to the NGS.
- 1.1.9.** Since all HAS Airports are owned and operated by the COH and are located in Harris County, some projects will have components and/or areas that are located outside of the AOA of the respective airport that are not specifically related to aviation activities. As such, the Surveyor must follow all applicable requirements of the COH Houston Public Works Department's Infrastructure Design Manual, Chapter 2 Survey Requirements, most recent edition (available online). The Surveyor will consult this manual and verify applicability with the HAS Project Manager prior to commencing work.
- 1.1.10.** Refer to other sections of the HAS Design Standards for additional requirements, including surveying of components related to civil infrastructure, exterior improvements and/or utilities, buildings, etc. Create all graphics and Computer Aided Design (CAD) files pursuant to the HAS CAD Standards.
- 1.1.11. Bridge Standards:** For vehicular and pedestrian bridge requirements, go to the Texas Department of Transportation (TxDOT) online site for the current bridge manual.

1.2. Quality Assurance

- 1.2.1.** Quality assurance will be built into any professional services provided to HAS by the Designer

and Contractor.

1.3. Shop Drawings and Submittals

1.3.1. Prepare and submit all drawings and submittals pursuant to the contract and project requirements.

1.4. Warranty

1.4.1. All work for the contract will be warranted pursuant to the requirements of the engineering or surveying professional licensure and the contract under which the work is performed.

Part 2 – Products

2.1. Information

2.1.1. Indicate project benchmark name(s), location, coordinates, and elevation along with horizontal and vertical reference datum. Per FAA AC 150/5300-18, all project benchmarks must be a local airport Primary Airport Control Station (PACS) or Secondary Airport Control Station (SACS). Other benchmarks may also be tied to determine datum conversion factors, but mapping must be created referenced to the PACS or SACS.

2.1.2. Establish acceptable vertical and horizontal project temporary control benchmarks referenced to PACS/SACS as necessary for project requirements.

2.1.2.1. Create horizontal control mapping and benchmark layouts to be included with the project documents signed and sealed by the Surveyor of Record and delivered to HAS.

2.1.2.2. Locate all features and improvements in the project area including, but not limited to; runway lighting fixtures, navigational aids, manholes, valves, drainage structures, power poles, power lines, signs, pavement striping, water meters, drainage ditches and swales, culverts, and fencing or any other improvements on subject site. Survey all curbs and other vertical structures like retaining walls at the bottom face, gutter line, and top of structure.

2.1.2.3. Label all line sizes, flow line (invert) elevations, pipe materials and pipe flow directions, show the direction of buried lines and connect to manholes, and inlets and structures where apparent. Infer direction where not apparent and indicate as such.

2.1.2.4. Survey spot elevations in unimproved or undeveloped open areas on the site on a grid appropriate for the area size (e.g., 25-, 50-, and 100-foot grid intervals), and as approved by the HAS Project Manager.

2.1.2.5. Include any inverts for all pipes in a manhole and label all pipe sizes and directions. Make notes of conditions inside manholes. Survey manhole rim elevations on manhole centers and at quadrants around perimeter.

2.1.2.6. Identify and survey any surface anomalies (sloughs, erosion areas, mounds, etc.) on a maximum 15-foot grid or as necessary to clearly define the limits and height of the anomaly. Show elevation contours at 1 foot intervals except as directed by the HAS Project Manager.

2.1.2.7. Identify all building, or structure, finished floor elevations including elevations at each building entrance. Survey the perimeter of any building and clearly identify all building corners. Survey all access (wheelchair) ramps and approaches to buildings using a maximum 3-foot grid, or as

necessary to define the transverse and cross-slope of the structure.

2.1.3. Planimetric Mapping and CAD Drawing Files:

- 2.1.3.1. Topographic, planimetric, and survey files will be three-dimensional (3D – X, Y and Z coordinates) point and breakline files in AutoCAD (*.DWG) formats.
- 2.1.3.2. Create all graphic deliverables using surface coordinates and HAS airport- specific scale factor. Clearly state the scale factor used in the mapping.
- 2.1.3.3. All resource files needed to manipulate the CAD files will be submitted with the CAD files including, but not limited to, all resource files, libraries, databases, etc.
- 2.1.3.4. The survey, or topographic file(s), will contain all surveyed benchmarks, control points, traverse data, site data points (spot elevations), and other reference data as appropriate. All spot elevations in the 3D point file will be inserted into the CAD file such that the origin of the marker is located at the actual surveyed coordinate of the spot elevation. The spot marker may be an “X” symbol, point, or other object that is easily discernible in the CAD environment as well as on printed maps. The origin of the spot will be the center of the object (center of circular spot or middle of “X”).
- 2.1.3.5. Each spot marker will have, at a minimum, the text attributes associated with it: Survey point number, elevation and object identification code (the type of object the spot is marking like edge of pavement, water meter, etc.). Follow HAS CAD standards for layering of CAD elements.
- 2.1.3.6. Use scalable, annotative plot styles, and plot scales.
- 2.1.3.7. All CAD files will use Relative Path for attaching reference files to a drawing.
- 2.1.3.8. All CAD drawing files will have a text block located in the model space of the drawing clearly indicating at a minimum:
 - The pertinent survey control used for the drawing,
 - The coordinated system used,
 - The vertical and horizontal data used, and
 - The surface-to-grid (grid-to surface) scale factors.
- 2.1.3.9. The Surveyor will submit all project data point sets in American Standard Code for Information Interchange (ASCII) format for the whole project.
- 2.1.3.10. The Surveyor will submit all field books and any other data gathered for the project.

Part 3 – Execution

3.1. Control and Execution of Work

- 3.1.1. The Surveyor will be required to complete the survey work in an orderly and controlled manner. The Surveyor must act according to the project milestones given by the HAS Project Manager or the Designer.
- 3.1.2. All work within the AOA requires special security clearance and badging from HAS, the FAA, and the Department of Homeland Security Customs and Border Protection (DHS CBP).
- 3.1.3. **Record Drawings and Subsurface Utility Engineering (SUE):**
 - 3.1.3.1. The Surveyor or SUE contractor will contact, research, and procure all available existing and proposed underground public and private utilities, and improvements.

- 3.1.3.2. Provide a comprehensive list of contacts and records of conversation with each in a computer spreadsheet and hard or electronic copies of all correspondence with utility companies to HAS.
- 3.1.3.3. Use the research to locate and delineate all above and underground improvements within the project boundary and within the adjacent Right(s)-of-Way (ROWs).
- 3.1.3.4. Review all existing plans and rectify the information to the existing site conditions surveyed.
- 3.1.3.5. Perform all utility notifications and markings from utility providers and locate/ identify all buried utilities on survey.
- 3.1.3.6. Indicate any possible abandoned utilities and clearly indicate where potential unidentified utilities may exist based on interviews with local entities.
- 3.1.3.7. Provide electronic copies of all record drawings to HAS, except those provided by HAS.

41- STORM DRAINAGE



41 - Storm Drainage

Part 1 – General

1.1. Overall

- 1.1.1. The intent of the Houston Airport System (HAS) drainage design criteria are to establish a baseline for drainage systems anywhere in the HAS system. This will help coordinate and augment the criteria used by the City of Houston (COH) and Harris County Flood Control District (HCFCD). A primary goal is to eventually convert or upsize the capacity of the entire storm sewer conveyance system within a specific airport, to the greatest extent possible, to a minimum five-year design rainfall frequency. It is understood that the ultimate extent will be determined by downstream conditions or other constraints outside the control of HAS.
- 1.1.2. The Engineer-of-Record (EOR) will consult the most recent edition of the respective Airport's Drainage Master Plan and Storm Water Quality Master Plan as guiding criteria for specific projects prior to commencing design. Coordinate any discrepancies between this document and the criteria. Obtain written verification of the criteria to be applied to each project prior to commencing design.
- 1.1.3. Check to see if the project is accounted for in the Airport Drainage Master Plan. If detention is already provided, verify the impervious area impacts allowed. If impervious area impacts have changed, work with HAS to determine if additional detention is needed.
- 1.1.4. Private developments constructed on Airport Property are normally not included in the Airport Drainage Master Plan. These projects will be required to provide on-site detention and control release of runoff. Verify the availability of detention with the HAS Project Manager.
- 1.1.5. Projects on any airport that have a Federal Emergency Management Agency (FEMA) delineated floodplain in their boundary, are subject to all requirements for detention and floodplain mitigation that any other project would have including required Letter of Map Revision (LOMR) and Conditional Letter of Map Revision (CLOMR).
- 1.1.6. Except as specifically allowed in writing by HAS, no off-site or off-Airport drainage system is allowed into any drainage facility owned, operated, or maintained by HAS.

1.2. Quality Assurance

- 1.2.1. All design criteria in this section will be reviewed by the EOR in charge of the design for applicability, validity, and usage on the project. The EOR will alert HAS regarding any conflicts that arise between these criteria and use engineering judgment in the context of the project design. The conflicts will be reviewed with HAS and resolved in writing prior to issuance of the construction documents. HAS will not be responsible for any fees that arise related to unresolved conflicts between the criteria and the EOR's judgment. HAS's agreement with the EOR's judgment does not relieve the EOR of responsibility for the design.

1.3. Shop Drawings and Submittals

- 1.3.1. **Drainage Report:** All drainage designs will be contained in a Drainage Report and submitted to the HAS Project Manager for review and approval. The Drainage Report will provide the basis for timely and consistent review and will be made a part of the permanent record for future evaluation as a chapter in

the Project Report. The drainage report will contain the following:

- 1.3.1.1. The descriptions and plans of existing drainage facilities.
- 1.3.1.2. The descriptions and plans of proposed drainage facilities, which may be half size reduction of preliminary or final design plans.
- 1.3.1.3. Drainage area map.
- 1.3.1.4. Description of analysis.
- 1.3.1.5. All calculations associated with the determination of runoff coefficients, volume of runoff, time of concentration, inlet size, culvert or pipe size and elevation of hydraulic gradient, discharge flow and velocity, and any other items pertinent to the drainage design.
- 1.3.1.6. Consideration of drainage alternatives and recommended facilities.
- 1.3.1.7. A certification signed and sealed by a Professional Engineer, registered in the State of Texas, means that the design procedure is in full compliance with the requirements of these criteria.
- 1.3.1.8. Description of measures taken for velocity dissipation to ensure non-erosive velocities at points of discharge.
- 1.3.1.9. All calculations associated with the drainage design will be included in tabular form in the final design plans.
- 1.3.1.10. The drainage area map will be on a scale no smaller than 1-inch equals 200 feet, and show all streets, building pads, and other existing and proposed features. The drainage area map will show the boundary of the drainage area contributing runoff into the proposed system. The area will be further divided into numbered sub-areas to determine flow concentration points or inlet location(s). Drainage area maps will show streets, land-use and land-use boundaries, existing ground elevations on 2-foot contours, and a summary table of peak design flows for sub-areas with acreage, runoff coefficient, and inlet time shown.
- 1.3.1.11. Quantity and direction of design flow within streets, alleys, natural and manmade drainage ways, and at all system intersections will be clearly shown on the drainage area map. Existing and proposed drainage inlets, storm drainage systems, and drainage channels will be clearly shown and differentiated on the drainage area map.

1.4. Warranty

- 1.4.1. All products and/or workmanship will be warranted for at least one year after the date accepted by HAS and the COH.

Part 2 – Products

2.1. Information

- 2.1.1. All utility crossings of aircraft loaded pavements, will be installed meeting aircraft rating requirements. Any structures within runway/taxiway safety areas will be aircraft rated.
- 2.1.2. **Proposed New Earthen Slope:** Maximum slow ration of 4:1 Horizontal:Vertical (H:V). Use slope paving when slopes exceed 4:1. Provide sodding, turf, erosion control per HAS landscaping, and planting criteria. Do not use grass species that attract wildlife. All new and retrofitted channels shall have a concrete-lined low flow flume at the bottom for maintenance purposes and limitation of wildlife.
- 2.1.3. **Concrete Slope Paving (Channel Lining):** Maximum 2:1 H:V. Design slope as a retaining wall when slopes exceed 2:1. Provide weep holes, toe walls, and transverse grade beams.

- 2.1.4. Side Slopes – Existing / Retrofit - Grassor Riprap:** Maximum 3:1 H:V; riprap only allowed in special circumstances as approved by HAS.
- 2.1.5. Access Ramp:** All channels that exceed 4:1 (H:V) for proposed structures or 3:1 (H:V) for existing structures, will have at least one concrete access ramp to allow for maintenance vehicles. Provide access stairs per HCFCD Policy, Criteria and Procedure Manual (PCPM).
- 2.1.6. Minimum Bottom Width - Major Open Channel:** 8 feet
- 2.1.7. Backslope Drainage:** All ponds and major drainage channels will have backslope swales with interceptor structures at maximum 500 - foot spacing. The spacing will be limited to 400 feet if dispersive clay is present. The presence and/or absence of dispersive clays will be determined for each project and project area by the Geotechnical EOR. Backslope swales will be as designed per HCFCD criteria.
- 2.1.8. Outfalls for Backslope Swales into Major Channel:** Design per HCFCD inlet/pipe combination or concrete flume. Do not use HCFCD timber bents or corrugated metal pipe.
- 2.1.9. Outfall Pipes / Boxes:** Daylight outfall pipes no higher than 12 inches above the top of the concrete pilot channel, in the receiving channel. Outfall pipes may match the receiving channel flowline if a pilot channel is present. If no pilot channel exists, the outfall pipe will outfall a minimum of 12 inches above the normal water surface or flowline of the receiving channel if possible. The receiving channel will have concrete slope paving constructed a minimum of 10 feet in width on either side of the outfall pipe, and on the opposite bank slope of the channel, if outfall waters are calculated to cause erosion on the opposite bank.
- 2.1.9.1. Bedding and Backfill:** All storm sewer pipes and culverts, box culverts, inlets, manholes, trench drains, and any other drainage structures will be bedded using cement stabilized sand. Drainage structures will be bedded at a depth of at least 1 foot above the exterior top of the pipe/box or 1 foot around the exterior perimeter of the inlet/manhole/structure.
- 2.1.10. Maintenance Berms:**
- 2.1.10.1. Channel Top Width Less Than 60 Feet:** 20 feet on each side of channel.
- 2.1.10.2. Channel Top Width Greater Than 60 Feet:** 30 feet on each side of channel.
- 2.1.11.** Storm sewers will be designed meeting the requirements of the COH Infrastructure Design Manual (IDM), except as superseded herein.
- 2.1.11.1. Manhole Spacing:** at maximum 400 feet.
- 2.1.11.2. Minimum Pipe/Box Size:** 24 inches inside diameter, 2 feet wide by 2 feet tall. Smaller pipes may be used only as approved by HAS for limited usage for interconnections, underdrains, etc.
- 2.1.11.3. Losses:** Compute manhole, junction, and bend losses within the system.
- 2.1.12.** Use only reinforced concrete pipe for 24-inch-diameter pipe and larger. Pipe must be designed appropriately for the loading anticipated. Refer to Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5320-5, or current edition.
- 2.1.13. Flow in Storm Drains and Their Appurtenances:** Storm drains will be designed to have a minimum mean velocity of 3 feet per second (fps) flowing full. Velocities greater than 13 fps will be avoided.
- 2.1.14.** Security grates, gates, or other similar devices are required on all drainage culverts and channels that cross the Airport Operations Area (AOA) boundary to prevent unauthorized access to the AOA. For storm drainage crossings within the boundary locations, no hydraulically operated grates, gates, fences, etc. will be permitted. Coordinate design with HAS.

2.2. Function

- 2.2.1. Drainage of Unpaved Areas Adjacent to Buildings:** Unpaved areas adjacent to buildings will be sloped, to direct surface water and roof drainage, away from buildings at a minimum of 5 percent in the first 10 feet of horizontal distance. Unpaved areas will be permanently stabilized with vegetative cover

to prevent erosion and soil loss. Surfaces paved with concrete or bituminous pavement will have a slope of no less than 0.5 percent in the direction of drainage, to prevent ponding. Paved areas adjacent to buildings that may have pedestrian traffic will be designed consistent with the requirements of the Texas Accessibility Standards and the American with Disabilities Act (ADA).

- 2.2.2. Drainage of Unpaved Areas Not Occupied by Buildings:** Portions of the site not occupied by buildings or pavement will have adequate continuous slopes to drain toward watercourses, drainage swales, roadways, and storm drainage inlets. Drainage swales or channels will be sized and sloped to accommodate the design runoff. Sheet flow across sidewalks is allowable when necessary due to site conditions but is discouraged. The concentrated runoff will be carried under walkways in pipes or by suitable sidewalk drains. Swales will be used to intercept water at the top and bottom of banks where large areas are drained. To provide positive drainage, a slope of no less than 2 percent for turfed areas is desirable. Slopes will be designed to ensure non-erosive runoff velocities. Turf banks, where required, will be graded to permit the use of gang mowers, providing a maximum slope of 4:1 H:V. The tops and bottoms of all slopes will be gently rounded in a transition curve for optimum appearance and ease of maintenance.
- 2.2.3.** Coordinate the design with entities receiving water from the system being designed, (e.g., downstream systems/outfalls) apply design criteria, and design methodology as appropriate. The capacity of the downstream storm sewer system may limit the design and/or require upsized pipes with restrictors to avoid overloading the downstream system. The downstream permitting authority may have authority to review and/or permit the design.
- 2.2.4. Storm Sewer Hydraulic Gradient:** Compute the hydraulic gradient and the water surface elevation for the 100-year storm event. Ensure the overflow or ponding area maintains a minimum of 75 feet from the edge of all aircraft pavements, including all runways, taxiways, aprons, hardstands, holding areas, etc.
- 2.2.5. Existing Storm Sewers:** For modeling purposes, analyze existing systems assuming they are designed to convey the 5-year peak discharge with hydraulic gradient at or below top of grate or inlet throat (minimum). If calculations prove the downstream system is not capable of conveying the 5-year storm event, EOR will alert the HAS Project Manager so alternate solutions can be reviewed and approved.
- 2.2.6. Downstream and Receiving Waters:** If the overall drainage system outfalls into HCFCD channel, HAS and HCFCD have designated control points. Control points are typically located at the airport boundary edge. Check that the 10- and 100-year peak flows do not exceed existing condition peak flows starting at the control points and continuing to three nodes downstream in the Hydrologic Modeling System (HEC-HMS).
- 2.2.7. Detention Basins:** Design to 100-year storm event for entire contributing area. Detention basins will incorporate water quality Best Management Practice's into basin design, but will in no way interfere with the function, operation, maintenance or rehabilitation of the facility. Trash screens are required at detention basins; coordinate design with HAS. All detention basins shall be designed to drain completely within 48 hours of a rainfall event, per FAA requirements.
- 2.2.8. Emergency Overflow Structures:** Provide concrete-lined, inflow and outflow, overflow structures for storms greater than a 100-year design storm event. Use structural concrete bollards as energy dissipaters as required by engineering analysis to moderate excessive velocities or erosive turbulence. Riprap will be used appropriately to prevent/mitigate erosive forces from undermining pavements.

2.3. Durability

- 2.3.1.** For the consideration of overland flow, the design will consider extreme storm events (100-Year storm events) that exceed the capacity of the storm sewer system. This will result in ponding and overland flow from the airport to the primary outfall, or off-system if applicable.

2.4. Sustainability

2.4.1. Major Open Channels: All open channels draining greater than 300 acres or as determined by HAS during project design:

2.4.1.1. **Landside and Airside:** Airside areas include the airfield, infield, midfield, and those partially or entirely located inside the AOA. Use 100-year design rainfall frequency, 1 percent Annual Exceedance Probability (AEP).

2.4.1.2. **Tailwater Elevation:** Use calculated elevations from models maintained and available from HCFCD's Model Map Management (M³) Program.

2.4.2. Minor Open Channels: All open channels draining less than 300 acres:

2.4.2.1. **Landside:** Use 5-year design rainfall frequency, 20 percent AEP.

2.4.2.2. **Airside:** Use 100-year design rainfall frequency, 1 percent AEP.

2.4.2.3. **Tailwater Elevation:** Use elevation from HCFCD M³ Program if available. Use 1 foot below top of bank at downstream node otherwise, or as recommended by the Designer and approved by HAS.

2.4.3. Major Culverts/Bridge Class Culverts/ Bridges

2.4.3.1. **Landside and Airside:** Use 100-year design rainfall frequency, 1 percent AEP.

2.4.3.2. **Bridge Class Culverts:** Design culverts are to limit upstream headwater effects, while limiting downstream impacts and water velocities, per the HCFCD Drainage Criteria Manual.

2.4.3.3. **Bridges:** Design bridges with freeboard requirements per the HCFCD Drainage Criteria Manual.

2.4.3.4. **Tailwater Elevation:** Use calculated elevations from the downstream receiving waters available from the HCFCD M³ Program.

2.4.4. Minor Culverts

2.4.4.1. **Landside Frequency:** Use 50-year design rainfall frequency, 2 percent AEP.

2.4.4.2. **Landside Tailwater:** Base the starting water surface on the normal depth in the downstream ditch.

2.4.4.3. **Airside Frequency:** Use 100-year design rainfall frequency, 1 percent AEP.

2.4.4.4. **Airside Tailwater:** Use elevation from the HCFCD M³ Program if available. Use 1 foot below top of bank at downstream node otherwise, or as recommended by the designer and approved by HAS.

2.4.5. Storm Sewers

2.4.5.1. Major Storm Sewers, closed conduits and drainage areas greater than 300 acres.

2.4.5.2. **Landside and Airside Frequency:** Use 100-year design rainfall frequency, 1 percent AEP, with hydraulic grade line (HGL) below the grate inlet or gutter.

2.4.5.3. Minor storm sewers, closed conduits, drainage areas less than 300 acres.

2.4.5.4. Landside minor storm sewers outside of AOA.

2.4.6. Inside Central Terminal Area (CTA)

2.4.6.1. Use 100-year design rainfall frequency, 1 percent AEP, with HGL below the grate inlet or gutter.

2.4.6.2. All inlets will meet the standards as found in COH Infrastructure Design Manual, computed using COH's HouStorm computer program or the Federal Highway Administration (FHWA) HEC-22, based on the 100 year design storm event. Coordinate with the HAS Project Manager to determine if the inlets and storm system is in the CTA.

2.4.7. Outside CTA

2.4.7.1. Use 5-year design rainfall frequency, 20 percent AEP, and analyze for the 100- year storm event consistent with COH Infrastructure Design Manual requirements for structural flooding.

2.4.7.2. All inlets will meet the standards as found in the COH Infrastructure Design Manual computed using

COH's HouStorm computer program or FHWA HEC-22 based on a 5-year design storm event.

2.4.8. Airside Minor Storm Sewers

- 2.4.8.1. Use the 100-Year Rainfall Intensity, 1 percent AEP. The HGL computed from the 100-year storm event will not exceed the top of any grate/area inlet in a paved area, accessible to aircraft or ground traffic, or the gutter/throat of any curb inlet. The HGL may exceed the top of area inlets in graded areas to the extent that it does not break other criteria in this Division. Except as specifically approved in writing by HAS, the computed ponded depth will not exceed the elevation that would cause backflow into any underdrain system or flood any pavement base course accessible to aircraft.
- 2.4.8.2. Capacity computed using COH's HouStorm computer program or FHWA HEC-22 based on 100-year design storm event.
- 2.4.8.3. All Airside grate inlets, and trench drains, will have their tops bolted down to prevent them from being displaced by aircraft or other means. All drains and grading will be designed meeting the requirements of all FAA and National Fire Protection Association (NFPA) 415 requirements for environmental, safety, and fire protection.
- 2.4.8.4. There must be a minimum of 75 feet from the edge of aircraft pavement, outside the Taxiway and the Runway Safety Area (RSA), in the infield/midfield areas of the AOA and must not be in the path of aircraft movement in the aprons or ramps. The spacing, size, and number of inlets must be determined to provide adequate opening capacity to convey the 100-year storm event runoff without ponding above the inlet opening. Inlets in no circumstances must act as a restrictor.

Part 3 – Execution

3.1. Installation

- 3.1.1. Follow industry common best practices.

3.2. Training

- 3.2.1. Provide to HAS all computer files used to create the model along with the program output. This information is used by HAS and HCFCD to maintain the accuracy and currency of the M³ Program. Output files from computer programs submitted without native design files will be rejected as incomplete submittals.

42- ARCHITECTURAL DOORS AND HARDWARE



42 - Architectural Doors and Hardware

Part 1 – General

1.1. Introduction

- 1.1.1.** This Houston Airport System (HAS) Design Standard addresses architectural doors and hardware, as applicable to all HAS facilities.
- 1.1.2.** The Designer will coordinate with HAS Operations for specific door and hardware requirements during the design stage of each project.

1.2. Summary

- 1.2.1.** This section includes commercial door hardware for swinging and other doors, cylinders for doors, electrified hardware and products furnished, but not installed, under this section. Coordinating, purchasing, delivering, and scheduling remain requirements of this Section.
- 1.2.1.1.** Section Includes: Finish Hardware for door openings, except as otherwise specified herein.
- Door hardware for steel (hollow metal) doors and frames.
 - Door hardware for aluminum doors and frames.
 - Door hardware for wood doors.
 - Door hardware for other doors indicated.
 - Keyed cylinders as indicated.
- 1.2.1.2. Intent of Hardware Groups**
- 1.2.1.2.1.** Should items of hardware not definitely specified be required for completion of the Work, furnish such items of type and quality comparable to adjacent hardware and appropriate for service required. Submit to Houston Airport System (HAS) for approval prior to installation. Where items of hardware are not definitely or correctly specified, and are required for completion of the Work, a written statement of such omission, error, or other discrepancy is to be submitted to the Designer, prior to date specified for receipt of bids for clarification by addendum; or, furnish such items in the type and quality established by this Standard, and appropriate to the service intended upon HAS approval
- 1.2.1.2.2.** This Standard is intended as a coordination document for all related trades. The Contractor will coordinate with all trades under the Contractor's contract and others that HAS is bringing in for future build-out for seamless transition.
- 1.2.1.3. Allowances**
- 1.2.1.3.1.** Refer to Division 01 for allowance amount and procedures.
- 1.2.1.4. Alternates**
- 1.2.1.4.1.** Refer to Division 01 for alternates and procedures.

1.3. Substitutions

1.3.1. Comply with Division 01.

1.4. Submittals

1.4.1. Comply with Division 01.

1.4.2. Special Submittal Requirements: Combine submittals of this Section with Sections listed below to ensure the “design intent” of the system/assembly is understood and can be reviewed together.

1.4.3. Product Data: Manufacturer’s specifications and technical data including the following:

1.4.3.1. Detailed specification of construction and fabrication

1.4.3.2. Manufacturer’s installation instructions

1.4.3.3. Wiring diagrams for each electric product specified. Coordinate voltage with electrical before submitting

1.4.3.4. Transmit catalog cut sheets with hardware schedule for HAS approval prior to ordering hardware for this section

1.4.4. Shop Drawings - Hardware Schedule: Transmit the detailed hardware schedule in a vertical format.

1.4.4.1. List groups and suffixes in proper sequence

1.4.4.2. Completely describe door and list architectural door number

1.4.4.3. Manufacturer, product name, and catalog number

1.4.4.4. Function, type, and style

1.4.4.5. Size and finish of each item

1.4.4.6. Mounting heights

1.4.4.7. Explanation of abbreviations and symbols used within schedule

1.4.4.8. Detailed wiring diagrams, specially developed for each opening, indicating all electric hardware, security equipment and access control equipment, and door and frame rough-ins required for specific opening

1.4.5. Templates: Submit templates and “reviewed Hardware Schedule” to door and frame supplier, security provider, and others as applicable to enable proper and accurate sizing and locations of cutouts and reinforcing.

1.4.5.1. Templates, wiring diagrams and “reviewed Hardware Schedule” of electrical terms to electrical for coordination and verification of voltages and locations.

1.4.6. Contract Closeout Submittals: Comply with Division 01 including specific requirements indicated.

1.4.6.1. Operating and Maintenance Manuals: Submit the following.

- Complete information in care, maintenance, adjustment, data on repair and replacement parts, and information on preservation of finishes.
- Catalog pages for each product.
- Name, address, and phone number of local representative for each manufacturer.
- Parts list for each product.

1.4.6.2. Final hardware schedule, edited to reflect, “As installed”.

- 1.4.6.3. As installed “Wiring Diagrams” for each piece of hardware connected to power, both low voltage and 110/120 volts.
- 1.4.6.4. One set of special tools required for maintenance and adjustment of hardware, including changing of cylinders.

1.5. Quality Assurance

1.5.1. Comply with Division 01.

- 1.5.1.1. Contractor to provide a statement of qualification for distributor and all installers.
 - 1.5.1.2. Statement of compliance with regulatory requirements and single source responsibility.
 - 1.5.1.3. **Distributor’s Qualifications:** Firm with three years’ experience in the distribution of commercial hardware.
 - 1.5.1.3.1. Distributor to employ full time Architectural Hardware Consultants (AHC) for the purpose of scheduling and coordinating hardware and establishing keying schedule.
 - 1.5.1.3.2. Hardware schedule will be prepared and signed by an AHC.
 - 1.5.1.4. **Installer’s Qualifications:** Firm with three years of experience in installation of similar hardware to that required for a specific project, including specific requirements indicated.
 - 1.5.1.5. **Regulatory Label Requirements:** Provide testing agency label or stamp on hardware for labeled openings.
 - 1.5.1.5.1. Provide Underwriters Laboratories (UL) listed hardware for labeled and 20 minute openings in conformance with requirements for class of opening scheduled.
 - 1.5.1.5.2. UL requirements have precedence over this Standard where conflicts exist.
 - 1.5.1.6. **Single Source Responsibility:** Except where specified in the hardware schedule, furnish products of only one manufacturer for each type of hardware.
- 1.5.2.** Review project for extent of finish hardware required to complete the work. Where there is a conflict between this Standard and the existing hardware, notify the Designer in writing and furnish hardware in compliance with the Standard unless otherwise directed in writing by the Designer.
- 1.5.3.** Contractor, hardware supplier and related trades to provide an outline plan for coordination, between this and all related trades, before this and all related work on the project is installed. Have preliminary and concurrent scheduled coordination meetings as required to facilitate this and a seamless installation.
- 1.5.4.** Coordinate the preparation of doors and frames for electrified hardware. This includes but is not limited to, door electrical chased, EPT/ Electric hinge, door contacts, frame and door prep, proper conduit and back boxes from the electrical supplier with pull strings, and related items from the security provider and electrical contractor as needed.
- 1.5.5.** All power supplied to be furnished with 24 volts of direct current (VDC) power for a low voltage dry contact input.
- 1.5.6.** Coordinate the hookup of electrified hardware items as listed below:
- 1.5.6.1. **For Electrified Panics:** The hardware supplier will have a low voltage qualified installer. The hardware supplier is to supply a power supply, with battery backup and enclosure at each identified location. The hardware supplier will hook up the electrified panics to the power supply designated for that door hardware set. The electrician is to provide a 110/120 volt circuit within 25 feet of the door for the power supply and hook it up to the circuit electrician at each identified location. The security contractor/installer is to hook up the card reader to the power supply and check everything for proper operation.
 - 1.5.6.2. **For Electrified Locks and Electric Strikes:** The hardware supplier is to install all electrified hardware as identified in the hardware schedule for hook up by the security provider at the frame side of the EPT or hinge and strike side of the frame. The electrician is to provide proper back

boxes, door and frame prep, and conduit with a pull string for security provider hookup. The Security Contractor/Installer is to run all wires from his power supply to the electric strike, lock and card reader and check for proper operation.

- 1.5.6.3. All doors and frames with hardware sets shown with or needing a concealed door contact for monitoring are to be prepped for a Sentrol 1076C style door contact switch. The electrician must provide conduit and a pull string for the security contractor to be able to install and hook up the contact without any exposed conduit or wires.
- 1.5.6.4. Coordinate with electrical contractor to provide the following but not limited to at all doors and frames with hardware sets having security components.
- Provide 1/2 inch flex conduit and pull string to the frame back box at the EPT prep.
 - Provide 1/2 inch flex conduit with a pull string to the top of each door frame showing a door contact in the hardware set.
 - Provide conduit with a pull string and a 4-inch by 4-inch or a 4-inch by 2-inch "Deep" flush mounted wall box for card readers, and any related wall access security items. Coordinate this box requirement with the security contractor/ installer.

1.6. Delivery, Storage, and Handling

1.6.1. Packing and Shipping: Comply with Division 01.

- 1.6.1.1. Deliver products in original unopened packaging with legible manufacturer's identification.
- 1.6.1.2. Package hardware to prevent damage during transit and storage.
- 1.6.1.3. Mark hardware to correspond with "reviewed hardware schedule".
- 1.6.1.4. Deliver hardware to door and frame manufacturer upon request.

1.6.2. Storage and Protection: Comply with manufacturer's recommendations.

1.7. Project Conditions

1.7.1. Coordinate Hardware With Other Work: Furnish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security and similar requirements indicated, as necessary for the proper installation and function, regardless of omissions or conflicts in the information on the Contract Documents.

1.7.2. Review shop drawings for doors and entrances to confirm that adequate provisions will be made for the proper installation of hardware.

1.8. Warranty

1.8.1. Manufacturer's Warranty:

- **Closers:** Ten years
- **Exit Devices:** Five Years
- **Locksets and Cylinders:** Three years
- **Mechanical Mortise Locksets:** Life Time Limited Warranty
- **Electric Locksets/Panics:** Two Years.

- **All other Hardware:** Two years.

1.9. Owner’s Instruction

1.9.1. Instruct HAS’ personnel in operation and maintenance of hardware units.

1.10. Maintenance

1.10.1. Extra Service Materials: Deliver to HAS extra materials from same production run as products installed. Package products with protective covering and identify with descriptive labels. Comply with Division 01 Closeout Submittals Section.

1.10.1.1. Special Tools: Provide special wrenches and tools applicable to each different or special hardware component.

1.10.1.2. Maintenance Tools: Provide maintenance tools and accessories supplied by hardware component manufacturer.

1.10.1.3. Delivery, Storage and Protection: Comply with HAS’ requirements for delivery, storage and protection of extra service materials.

1.10.2. Maintenance Service: Submit for HAS’ consideration maintenance service agreement for electronic products installed.

Part 2 – Products

2.1. Manufacturers

2.1.1. The following manufacturers are approved subject to compliance with requirements of the Contract Documents. Approval of manufacturers other than those listed will be requested in writing to HAS prior to bidding and installation.

Items	Mfg. in HW sets	Approved Mfg.
Hinges	Stanley	Ives, McKinney
Continuous Hinges	Stanley	Ives, Select
Locksets & Cylinders	Best	No Substitute
Auto Operator Doors	Stanley	No Substitute
Exit Devices	Precision	Von Duprin
Electric Strikes	HES/Folger Adam	Security Door Controls, TRINE
Pulls	Rockwood	Trimco
Closers	Stanley	LCN, Norton

Stops	Rockwood	Trimco
Coordinators- Flushbolts	ABH	Rockwood, Trimco
Overhead Stops	ABH	Rockwood
Gasketing	National Guard	Pemco, Reese, Zero

2.2. Materials

2.2.1. Hinges and Pivots:

- Template screw hole locations
- Minimum of two permanently lubricated non-detachable bearings
- Equip with easily seated, non-rising pins
- Sufficient size to allow 180-degree swing of door
- Furnish hinges with five knuckles and flush (concealed) bearings
- Provide Non-Removable Pins (NRP) where required
- Provide hinge type as listed in schedule
- Tested and approved by Builders Hardware Manufacturers Association (BHMA) for all applicable American National Standards Institute (ANSI) for type, size, function and finish
- UL10B listed for Fire

2.2.1.2. Manufacturers subject to compliance with requirements, provide products by one of the following:

- **Pivot Hinges:** NOT ALLOWED
- **Concealed Rods:** Prior Approval Required
- **Surface Rods:** Prior Approval Required
- **Hinges:** Stanley, Ives, Hager, or McKinney
 - **Conventional Hinges:** Steel or stainless-steel pins and concealed ball bearings. Hinge open widths minimum, but of sufficient throw to permit maximum door swing.
 - Three hinges per leaf to 7 foot, 6 inch height. Add one hinge for each additional 30 inches in height, or any fraction thereof.
 - Extra heavy weight hinges on doors over 3 foot, 5 inches in width.
 - Extra heavy weight hinges on doors with panic hardware or fire exit devices.
 - Extra heavy weight hinges on restroom, locker, gym, and other high frequency openings.
 - Out swinging exterior doors: non-ferrous with NRP.
 - Non-ferrous material exteriors and at doors subject to corrosive atmospheric conditions.
 - 5 inch tall hinge at openings over 36 inches in width.
- **Continuous Hinges (Stainless-Steel):** Stanley, Select, or Ives.
- **Continuous Hinges: Geared-type aluminum at exteriors.**

- Heavy-duty, extra-bearing units for doors over 3 foot, 5 inches in width.
- Heavy-duty, extra-bearing units for doors with panic hardware or fire exit devices.

2.2.1.3. Standards: BHMA Certified products complying with the following:

- Butts and Hinges: BHMA A156.1
- Continuous Geared Hinges: BHMA A156.26
- Template Hinge Dimensions: BHMA A156.7
- Self-Closing Hinges: BHMA A156.17
- Floor Hinges: BHMA A156.4

2.2.1.4. Quantity: Provide the following, unless otherwise indicated:

- Two Hinges: For doors with heights up to 60 inches.
- Three Hinges: For doors with heights 61 to 90 inches.
- Four Hinges: For doors with heights 91 to 120 inches.
- For doors with heights more than 120 inches, provide four hinges, plus one hinge for every 30 inches (of door height greater than 120 inches).

2.2.1.5. Flush Floor Plates and Thresholds:

Provide finish cover plates or thresholds

as indicated in door hardware sets for floor hinges. Match door hardware finish, unless otherwise indicated.

2.2.1.6. Hinge Size: Provide the following, unless otherwise indicated, with hinge widths sized for door thickness and clearances required:

Maximum Door Size (inches)	Hinge Ht. (inches)	Standard Wt.	Heavy Wt.
36 by 86 by 1-3/4	4-1/2	0.134	0.180
<36 by 120 by 1-3/4	5	0.146	0.190

2.2.1.7. Hinge Weight and Base Material: Unless otherwise indicated, provide the following:

- **Exterior Doors:** Heavy weight, non-ferrous, ball bearing hinges.
- **Interior Doors:** Heavy weight, ball bearing hinges unless Hardware Sets indicate standard weight.

2.2.1.8. Hinge Height Clarifications: Where uneven door leaves occur, the widest door leaf must be used to determine the height of the hinges on the inactive and active door leaves; to ensure equal size hinges on opening.

2.2.1.9. Hinge Weight Clarification: If heavy weight hinges are specified in hardware sets for aluminum frames then standard weight hinges can be used. If aluminum frame openings are 42 inches and greater, then an additional hinge must be used in lieu of heavy weight hinges.

2.2.1.10. Hinge Options: Comply with the following where indicated in the Door Hardware Schedule or on Drawings:

- **Non-removable Pins:** Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for the following applications:

- Out-swinging exterior doors
- Out-swinging access-controlled doors
 - **Electric Hinges:** Provide electric transfer hinges with standardized plug connectors to accommodate up to 12 wires. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Provide enough concealed wires to accommodate electric function of specified hardware. Wire nut connections are not acceptable.
- Provide mortar guard enclosure on frames at each electrical hinge location specified.

2.2.2. Geared Continuous Hinges:

- Tested and approved by BHMA for ANSI A156.26-1996 Grade 1
- Anti-spinning through fastener
- UL10B listed for 3 hour Fire rating
- Non-handed
- Lifetime warranty
- Provide Fire Pins for 3-hour fire ratings
- Sufficient size to permit door to swing 180 degrees

2.2.3. Mortis Type Locks and Latches:

- 2.2.3.1. Tested and approved by BHMA for ANSI A156.13, Series 1000, Operational Grade 1, Extra-Heavy Duty, Security Grade 2 and be UL10C.
- 2.2.3.2. Fit ANSI A115.1 door preparation.
- 2.2.3.3. Functions and design as indicated in the hardware groups.
- 2.2.3.4. Solid, one-piece, 3/4-inch (19 millimeter) throw, anti-friction latchbolt made of self-lubricating stainless-steel.
- 2.2.3.5. Deadbolt functions will have 1 inch (25 millimeter) throw bolt made of hardened stainless-steel.
- 2.2.3.6. Latchbolt and Deadbolt are to extend into the case a minimum of 3/8 inch (9.5 millimeter) when fully extended.
- 2.2.3.7. Auxiliary deadlatch to be made of one piece stainless-steel, permanently lubricated.
- 2.2.3.8. Provide sufficient curved strike lip to protect door trim.
- 2.2.3.9. Lever handles must be of forged or cast brass, bronze or stainless-steel construction and conform to ANSI A117.1. Levers that contain a hollow cavity are not acceptable.
- 2.2.3.10. Lock will have self-aligning, thru-bolted trim.
- 2.2.3.11. Levers to operate a roller bearing spindle hub mechanism.
- 2.2.3.12. Furnish all locks with brass construction cores. Plastic cores are not acceptable.
- 2.2.3.13. Mortise cylinders of lock will have a concealed internal setscrew for securing the cylinder to the lockset. The internal setscrew will be accessible only by removing the core, with the control key, from the cylinder body.
- 2.2.3.14. Spindle to be designed to prevent forced entry from attacking of lever.
- 2.2.3.15. Provide locksets with 7-pin removable and interchangeable core cylinders.
- 2.2.3.16. Each lever to have independent spring mechanism controlling it.
- 2.2.3.17. Core face must be the same finish as the lockset.

2.2.4. Cylindrical Type Locks and Latchsets:

- 2.2.4.1. Tested and approved by BHMA for ANSI A156.2, Series 4000, Operational Grade 1, Extra-

Heavy Duty, and be UL10C listed.

- 2.2.4.2. Fit modified ANSI A115.2 door preparation.
- 2.2.4.3. Locksets and cores to be of the same manufacturer to maintain complete lockset warranty.
- 2.2.4.4. Locksets to have anti-rotational studs that are thru-bolted.
- 2.2.4.5. Keyed lever will not have exposed “keeper” hole.
- 2.2.4.6. Each lever to have independent spring mechanism controlling it.
- 2.2.4.7. 2-3/4 inch (70 millimeter) backset.
- 2.2.4.8. 9/16 inch (14 millimeter) throw latchbolt
- 2.2.4.9. Outside lever sleeve to be seamless, of one-piece construction made of a hardened steel alloy.
- 2.2.4.10. Keyed lever to be removable only after core is removed, by authorized control key.
- 2.2.4.11. Provide locksets with 7-pin removable and interchangeable core cylinders.
- 2.2.4.12. Furnish all locks with brass construction cores. Plastic cores are not acceptable.
- 2.2.4.13. Hub, side plate, shrouded raised locking pin to be a one-piece casting with a shrouded locking lug.
- 2.2.4.14. Locksets outside locked lever must withstand a minimum 1400 inch pounds of torque. In excess of that, a replaceable part will shear. Key from outside and inside lever will still operate lockset.
- 2.2.4.15. Core face must be the same finish as the lockset.
- 2.2.4.16. Functions and design as indicated in the hardware groups.

2.2.5. Electrified Locks:

2.2.5.1. **Manufacturers:** Subject to same compliance standards and requirements as mechanical locksets, provide products by one of the following:

- **Electromechanical Mortise Locks:** Best Access Solutions (BE) – 45HW EL/ EU - No Substitutions
- **Electromechanical Cylindrical Locks:** Best Access Solutions (BE) – 93K EL/ EU Series - No Substitutions

2.2.5.2. **Electrified Options:** As indicated in hardware sets, provide electrified lock options including: outside door trim control, latchbolt and lock/unlock status monitoring, and request-to-exit signaling. Unless otherwise indicated, provide electrified locksets standard as fail secure.

2.2.5.3. **Keypad Electronic Locks:**

- **Electromechanical Mortise Locks:** Best Access Solutions (BE) – Keypad EZ – (for Mechanical/Comfort Systems areas where required).

2.2.5.4. **Optional Wireless Locksets:** Wireless Access Control Devices where requested to tie to existing HAS Maintenance Access Control. Provide key override, low-battery detection and warning, LED status indicators, and required portal gateways for coverage range.

2.2.5.5. **Wireless Electronic Locks:** Best Access Solutions (BE) – WiQ Series

2.2.6. Exit Devices:

2.2.6.1. Will be tested and approved by BHMA for ANSI 156.3, Grade 1.

2.2.6.2. Provide a deadlocking latchbolt.

2.2.6.3. Non-fire rated exit devices will have cylinder dogging.

2.2.6.4. Touchpad will be “T” style.

2.2.6.5. Exposed components will be of architectural metals and finishes.

2.2.6.6. Lever design will match lockset lever design.

2.2.6.7. Provide strikes as required by application.

2.2.6.8. Fire exit devices to be listed for UL10C.

- 2.2.6.9. UL listed for Accident Hazard.
- 2.2.6.10. Panics with card readers will have a rim electric strike TRINE number 4850 or HES 9500 on fire doors. Unless specifically requested to have ELR.
- 2.2.6.11. Panics with electric latch retraction will have a TS Request to Exit in the bar and an EPT power transfer.
- 2.2.6.12. Provide vandal resistant or breakaway trim.
- 2.2.6.13. Aluminum vertical rod assemblies are acceptable only when provide with the manufacturers optional top and bottom stainless steel rod guard protectors.
- 2.2.6.14. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
- **Precision (PR):** 2000 Series
 - **Von Duprin (VO):** 35A/98 Series
- 2.2.6.15. **Exit Device Pull Lever:**
- **Precision Hardware (PHI):** 1700A/4900A
 - **Von Duprin (VO):** 697/994L
- 2.2.6.16. **Electrified Options:** As indicated in hardware sets, provide electrified exit device options including: motorized electric latch retraction, outside door trim control, exit alarm, delayed egress, latchbolt monitoring, lock/unlock status monitoring, touchbar monitoring and request-to-exit signaling. Unless otherwise indicated, provide electrified exit devices standard as fail secure.
- 2.2.6.17. **Standard:** BHMA A156.3.
- 2.2.6.18. **Exit Devices:** BHMA Certified Grade 1
- 2.2.6.19. **Panic Exit Devices:** Listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305.
- 2.2.6.20. **Fire Exit Devices:** Complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252.
- 2.2.6.21. **Dummy Push Bar:** Non-functioning push bar matching functional push bar.
- 2.2.6.22. **Outside Trim:** Match design for locksets and latchsets, unless otherwise indicated.
- 2.2.6.23. **Through Bolt Installation:** For exit devices and trim as required for fire rated wood doors.
- 2.2.6.24. **Gate Hardware:** All exit devices to match type and manufacture of exit devices located on exterior and interior doors of building.

2.2.7. Accessories for Pairs of Doors:

- 2.2.7.1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
- **Coordinators:**
 - Rockwood Manufacturing (RO)
 - ABH
 - Trimco
 - **Keyed Removable Mullions:**
 - Precision KR 822
 - Von Duprin (VO) KR4954 Series

2.2.7.2. **Standards:** Comply with the following:

- **Coordinators:** BHMA A156.3
- **Removable Mullions:** BHMA A156.3

2.2.7.3. **Fire-Exit Removable Mullions:** Provide keyed removable mullions for use with fire exit devices complying with NFPA 80

that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252. Mullions will be used only with exit devices for which they have been tested.

2.2.8. Closers and Power Operators:

2.2.8.1. **Manufacturers:** Subject to compliance with requirements, provide products by one the following: Surface-Mounted Closers (Heavy Duty): BHMA Certified Grade 1:

- **Stanley:** D4550 Series
- **LCN Door Closers (LC):** 4040XP Series
- **Norton Door Controls (NO):** 7500

2.2.8.2. **Surface-Mounted Closers (Standard Duty):** BHMA Certified Grade 1:

- **Stanley:** D3550 Series
- **LCN Door Closers (LC):** 1461 Series
 - **Norton Door Controls (NO):** 8501 BF Series

2.2.8.3. **Closer Holder Release (Detector) Devices:** BHMA Certified Grade 1:

- **LCN Door Closers (LC):** 4040SE Series
- **Norton Door Controls (NO):** 7700PT (D) Series.

2.2.8.4. **Power Assist Operators:** BHMA Certified Grade 1:

- **Stanley (ST):** Magic Force Series

2.2.8.5. **Door Closers Will:**

- Conform to ANSI 117.1
- Tested and approved by BHMA for ANSI 156.4, Grade 1
- UL10C certified
- Closer will have extra-duty arms and knuckles
- Conform to ANSI 117.1
- Maximum 2 7/16 inch case projection with non-ferrous cover
- Separate adjusting valves for closing and latching speed, and back check
- Provide adapter plates, shim spacers and blade stop spacers as required by frame and door conditions
- Full rack and pinion type closer with 1½ minimum bore
- Mount closers on non-public side of door, unless otherwise noted in specification
- Closers will be non-handed, non-sized and multi-sized 1 through 6

- 2.2.8.6. **Power Operators:** BHMA A156.19. Power operators to comply with TAS 404.3.
- 2.2.8.7. **Size of Units:** Unless otherwise indicated, comply with manufacturer's written recommendations for sizing of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide non-handed, factory-sized closers adjustable to meet field conditions and requirements for opening force.
- 2.2.8.8. **Closer Options:** As indicated in hardware sets, provide door closer options including: delayed action, hold open arms, extra duty parallel arms, positive stop/hold open arms, compression stop/hold open arms, special mounting brackets, spacers and drop plates. Through bolt type mounting is required as indicated in the door hardware sets.
- 2.2.8.9. Power assist operators as surface mounted, electric low energy type conforming to ANSI A156.19 requirements and capable of meeting ANSI A117.1 guidelines. Outputs and relays required to be on board in the operator to allow for coordination of exit device latch retraction, electric strikes, magnetic locks, card readers, safety and motion sensors and specified auxiliary contacts.
- 2.2.8.9.1. Outputs and relays on board the operator allow for coordination of exit device latch retraction, electric strikes, magnetic locks, card readers, safety and motion sensors and specified auxiliary contacts.
- 2.2.8.9.2. Electronic controls to be microprocessor controlled unit will control the operation and switching of the swing power operator. The electronic control provides low voltage power supply for all means of actuation. Electronic encoder to determine absolute open and close position.

2.2.9. Operating and Protective Trim Units:

2.2.9.1. Metal Protective Trim Units:

- Rockwood Manufacturing (RO)
- Ives
- Trico (TR)

2.2.9.2. Standard: Comply with BHMA A156.6

2.2.9.3. Materials: Fabricate protection plates from the following:

- **Brass/Bronze and Stainless-Steel:** .050 inches thick, beveled four sides (B4E) with countersunk screw holes.

2.2.9.4. Push-Pull Design: 1-inch Round with 10 inch Centers. Provide 90-degree offset pulls at exterior openings.

2.2.9.5. Fasteners: Provide manufacturer's designated fastener type as indicated in door hardware sets.

2.2.9.6. Furnish protection plates sized 1 1/2 inches less than door width (LDW) on push side and 1 inch less door width on pull side by height specified in door hardware sets.

2.2.10. Stops and Holders:

2.2.10.1. Stops and Holders:

- Rockwood Manufacturing (RO)
- Hager
- Trimco Manufacturing (TR) 1201, 1209, & 1277
- Ives FS448, FS18S, & 407B

2.2.10.2. Standards: Comply with the following:

- **Stops and Bumpers:** BHMA A156.16
- **Electromagnetic Door Holders:** BHMA A156.15
- **Combination Overhead Holders and Stops:** BHMA A156.8
- **Door Silencers:** BHMA A156.16.3

2.2.10.3. **Stops and Bumpers:** BHMA Certified Grade 1.

2.2.10.4. **Electromagnetic Door Holders for Labeled Fire Door Assemblies:** Coordinate with fire detectors and interface with fire alarm system. Magnetic door holders will meet or exceed ANSI A156.15 and be UL listed 228 for Door Closer and Holders, with or without integral smoke detectors. Holding force will be 25 to 40 pounds and will be fail- safe. Pushpin release that eliminates residual magnetism will be standard. Provide magnetic hold-opens with triple-voltage coil that can receive 12 VDC, 24 VAC/DC, or 120VAC; or coordinate required voltage with electrical. Subject to compliance with requirements, provide products by one of the following:

- **Rixson Hardware (RX):** 980 Series
- **ABH:** 2000 Series
- **LCN (LC):** SEM7800 Series

2.2.10.5. **Floor Stops:** For doors, unless wall or other type stops are scheduled or indicated. Do not mount floor stops where they will impede traffic.

2.2.10.5.1. Where floor or wall stops are not appropriate, provide overhead stops.

2.2.11. Door Thresholds, Weatherstripping and Gasketing:

2.2.11.1. Door Thresholds, Weather stripping and Gasket Seals:

- NGP Manufacturing (NG)
- Pemko Manufacturing (PE)
- Reese

2.2.11.2. **Standard:** Comply with BHMA A156.22.

2.2.11.3. **General:** Provide continuous weatherstrip seal on exterior doors and smoke, light, or sound gasketing on interior doors where specified. Provide non-corrosive fasteners for exterior applications.

2.2.11.4. **Perimeter Gasketing:** Apply to head and jamb, forming seal between door and frame. Install header seal before mounting door closer arms.

2.2.11.5. **Meeting Stile Astragals: Fasten to meeting stiles, forming seal when doors are closed.**

2.2.11.6. **Door Sweep:** Apply to bottom of door, forming seal with threshold when door is closed.

2.2.11.7. **Basic Sound Seal Requirement:** Whether indicated on the drawings or not, provide gasketing MCKS88BL at sound rated wall types and at the following areas for limiting of sound transmission: private offices, exams, conference, private toilets, corridor openings, rooms and similar sound sensitive area.

2.2.11.8. **Smoke Labeled Gasketing:** Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke control ratings indicated, based on testing according to UL 1784.

2.2.11.9. Provide smoke labeled perimeter gasketing at all smoke labeled openings.

2.2.11.9.1. **Fire Labeled Gasketing:** Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UL-10C.

2.2.11.10. Intumescent Seals and Gasketing: Provide concealed, Category A type gasketing systems on assemblies where an intumescent seal is required to meet IBC and UL-10C positive pressure labeling.

2.2.12. Power Supplies:

2.2.12.1. Provide Nationally Recognized Testing Laboratory Listed 12VDC or 24VDC (field selectable) filtered and regulated power supplies. Modular unit in NEMA ICS 6, Type 4 enclosure. Provide the least number of units, at the appropriate amperage level, sufficient to exceed the required total draw for the specified electrified hardware and access control equipment. Third party listed and labeled for use with fire alarm systems. Power supply will be furnished with a minimum of four 4 Amp/hour batteries providing battery back-up. An integral battery charging circuit will be standard. Provide key locking cover to prevent tampering. Provide all control boards and relay panels to sufficiently operate the opening as described and intended per hardware sets. Subject to compliance with requirements, provide products by one of the following:

2.2.12.2. Boxed Power Supplies:

- Altronix
- Precision (PR)
- Von Duprin (VD)
- Securitron Door Controls (SE)

2.2.13. Electric Door Cords:

2.2.13.1. Electric Door Hardware Cords: Furnish electric transfer wiring with plug connectors to match door hardware connectors. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Provide enough concealed wires to accommodate electric function of specified hardware. Provide a connector for through-door electronic locking devices and another one for hinge to junction box above the opening. Wire nut connections are not acceptable at low voltage electrified hardware. Determine the length required for each electrified hardware component for the door type, size and construction, minimum of two per electrified door:

- **Stanley (ST):** Quick Connect Harnesses

2.2.14. Electric Wall Mount Keyswitches:

2.2.14.1. Keyswitches will be furnished on a stainless steel single gang face plate. Keyswitches will be available for momentary or maintained action. Subject to compliance with requirements, provide products by one of the following:

2.2.14.2. Electric Wall Mount Keyswitches:

- **Best Access Solutions (BE):** 1W Series
- **Security Door Controls (SE):** 700 Series w/ Best Cylinder
- **Locknetics (LO):** 650 Series

2.2.14.3. Kickplates: Provide with four beveled edges, 8 inches high by width less 2 inches on single doors and 1 inch on pairs of doors. Furnish oval-head countersunk screws to match finish. Furnish Kickplates in high traffic areas and designated doors. No Kickplates in the office areas.

2.2.14.4. Lockable Millwork cabinets to receive Best 5L-7R-D Cabinet locks w/ Brass construction cores. Order with Vertical R or L and up or Inverted deadbolts as required by the cabinet layout. Furnish and provide to the GC for the Millwork supplier to install in his cabinets.

2.2.14.5. Seals: All seals will be finished to match adjacent frame color. Seals will be furnished as listed in schedule. Material will be UL listed for labeled openings.

2.2.14.6. Key Control: Provide one wall mounted key cabinet complete with hooks, index and tags with

- 150 percent of capacity. The cabinet lock must accept a BEST cylinder core. Lund 1200 series.
- 2.2.14.7. Keyswitch for Motorized Auto OH rollup doors supply SDC 700 series key switch x Best Mortise Cylinder 1E-72-C4 cam
- 2.2.14.8. **Key Control Software:** Provide Best Keystone software code import for the key code download with this bid from the Best Factory representative.
- 2.2.14.9. At all Single Security doors, that swing out toward the card reader side, supply a Lock Guard Astragal to secure the latch bolt from tampering Supply Folger Adams 310-2-3 to match the electric strikes.
- 2.2.14.10. **Silencers:** Furnish silencers on all interior frames, three for single doors, and two for pairs. Omit where any type of seals occurs.

2.3. Finishes

- 2.3.1. Designations used in Schedule of Finish Hardware and elsewhere to indicate hardware finishes are those listed in ANSI/ BHMA A156.18 including coordination with traditional U.S. finishes shown by certain manufacturers for their products
- 2.3.2. Powder coat door closers to match other hardware, unless otherwise noted.
- 2.3.3. Generally, BHMA 626 Satin Chromium, verify with each project type.
- 2.3.4. Areas using BHMA 626 to have push plates, pulls, exit devices, vandal trim, and protection plates of BHMA 630 Satin Stainless Steel, unless otherwise noted.
- 2.3.5. **Door Closers:** Factory powder coated to match other hardware, unless otherwise noted.
- 2.3.6. **Aluminum Items:** Match predominant adjacent material. Seals to coordinate with frame color.

2.4. Keys and Keying

- 2.4.1. Provide ONLY keyed brass construction cores and keys, for all locks, cylinders and padlocks, during the construction period. Construction control and operating keys and core will not be part of the HAS' permanent keying system or furnished in the same keyway (or key section) as the HAS's permanent keying system. Permanent cores and keys (prepared according to the accepted keying schedule) will be furnished to the HASs local representative.
- 2.4.2. **Cylinders, Removable and Interchangeable Core System:** Best PATENTED CORMAX 7-pin key system. Cores provided under the BEST keyway. Permanent cores priced with the locks and cylinders in this section. Permanent keys and cores: Stamped with the applicable key mark for identification. These visual key control marks or codes will not include the actual key cuts. Permanent keys will also be stamped "Do Not duplicate."
- 2.4.3. Transmit Grand Masterkeys, Masterkeys and other Security keys to HAS by Registered Mail, return receipt requested.
- 2.4.4. Furnish keys in the following quantities:
- Seven each Grand Masterkey for each Facility
 - Four each SUB-Masterkeys
 - Two each Change keys each keyed core
 - 15 each Construction masterkeys
 - One each Construction control key
 - One each Control key

- One each Permanent keyed core for the key cabinet lock
- One each Permanent keyed core for each turn style access panel lock
- One each Permanent Keyed Core for each Cabinet style lock
- One each Brass Construction Core for each keyed lock and cylinder
- 10 cylinder cores keyed to the next five key cuts as directed by HAS.

2.4.5. HAS Lock Shop to install the permanent cores and return the construction cores to the Hardware Supplier. Construction cores and keys remain the property of the Hardware Supplier.

2.4.6. Keying Schedule: Arrange for a keying meeting, and programming meeting with HAS OWNER REPRESENTATIVE and BEST ACCESS SOLUTIONS, and other involved parties to ensure locksets and locking hardware, are functionally correct and keying and programming complies with project requirements. Furnish three typed copies of keying and programming schedule to HAS.

2.4.7. Provide Patented, High, Security cylinders utilizing a unique factory code pattern that is both geographically and time zoned protected. A letter of authorization under the letterhead of the End User must accompany purchases of any products which involve patented cylinders, keys and accessories. Manufacturers of patented

security cylinders to allow the ability for both security and conventional cylinders to be used together under the same facility master or grandmaster key system. The End User is required to have the ability for on-site cylinder pinning and original key cutting.

2.4.8. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- **Patented Cylinders:**
 - **Best Access Systems (BE):** CORMAX Patented Core with Best Cylinders - No Substitutions

2.5. Keying Requirements

2.5.1. Keying: Lock core keying schedules must be as simple as possible and must fall under the HAS grand master for all HAS locks. The A/E must confirm the keying plan for each school with the HAS Lock Department.

2.5.2. Construction Keying: Furnish keyed-alike temporary cores plus 10 operating keys. Temporary cores and keys remain property of hardware supplier.

2.5.3. Interchangeable Cores: 7-pin solid brass construction.

2.5.4. Permanent Cores: Furnish factory-keyed.

2.5.5. Match the existing keyway for the HAS.

2.5.6. Permanent Keys and Cores: Use secured shipment direct from point of origination to HAS.

2.5.7. Biting List: Provide a key-biting schedule. Use secured shipment direct from point of origination to HAS upon completion.

2.5.8. Key Cabinet: Provide a key cabinet. Confirm mounting location in a secure area.

2.5.9. IC Core: BHMA A156.5

2.5.10. Key Control System: BHMA A156.5

2.5.11. Cylinder Grade: BHMA Certified Grade 1

2.5.12. Permanent Cores: Manufacturer's standard; finish face to match lockset; complying with the following:

- **Removable Cores:** Core insert, removable by use of a special key, and for use with only the core manufacturer's cylinder and door hardware.

- **Construction Master Keying:** Provide temporary construction master keyed cores that are replaceable by permanent cores.

2.5.13. Keying System: Unless otherwise indicated, provide for a keying system complying with the following requirements:

2.5.13.1. To Match HAS Grand Master Key System: Cylinders are factory keyed operated by a change key, master key, and a grand master key. Conduct keying meeting with End User to define and document keying system instructions and requirements.

2.5.13.2. Keys: Provide nickel-silver keys complying with the following:

- **Stamping:** Permanently inscribe each key with a visual key control number and as directed by HAS.
- **Quantity:** Supply additional materials to comply with HAS key system.
- **Extra Uncombined Cores:** 10
- **Extra Blank Keys:** 50

2.5.14. Key Registration List: Provide keying transcript list to HAS's representative for lock cylinders.

2.5.15. Key Control System: Provide one lockable cabinet for key control complete with hooks, index and tags with 150 percent capacity. The cabinet lock must accept a BEST IC core.

2.6. Cabinet Locks

2.6.1. Lockable Millwork Cabinets to receive Best 5L7RD cabinet locks w/ Brass construction cores. Coordinate with GC and Millwork Supplier.

2.7. Strikes

2.7.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- **Electric Strikes:** BHMA Certified Grade 1
- **Hanchett Entry Systems (HE):** 1000, 5900, 9600 Series
- **Trine:** 4800 Series

2.7.2. Standards: Comply with the following:

- **Strikes for Bored Locks and Latches:** BHMA A156.2
- **Strikes for Mortise Locks and Latches:** BHMA A156.13
- **Strikes for Interconnected Locks and Latches:** BHMA A156.12
- **Strikes for Auxiliary Deadlocks:** BHMA A156.5
- **Dustproof Strikes:** BHMA A156.16
- **Electric Strikes:** BHMA A156.5

2.7.3. Strikes: Provide manufacturer's standard strike with strike box for each latch or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, unless otherwise indicated, and as follows:

2.7.3.1. Flat-Lip Strikes: For locks with three-piece anti-friction latchbolts, as recommended by manufacturer.

- 2.7.3.2. **Extra-Long-Lip Strikes:** For locks used on frames with applied wood casing trim.
- 2.7.3.3. **Aluminum-Frame Strike Box:** Provide manufacturer's special strike box fabricated for aluminum framing.
- 2.7.4. Provide electrified products with an in-line power controller that enables the hardware to operate from 12 to 32 volts. On board safety features will include an in-line fuse to protect the hardware and host system from any possible reverse current surges. The controller will regulate current to provide continuous duty operation without the typical head build up. Adding the in-line power controller with electrified products provides unlimited lifetime warranty of electrified products.

Part 3 – Execution

3.1. Examination

- 3.1.1. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.
- 3.1.2. Examine roughing-in for electrical source power to verify actual locations of wiring connections before electrified door hardware installation.
- 3.1.3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. Hardware Locations

- 3.2.1. Mount hardware units at heights indicated in the following publications except as specifically indicated or required to comply with the governing regulations.
- Recommended Locations for Builder's Hardware for Standard Steel Doors and Frames, by the Door and Hardware Institute (DHI).
 - NWWDA Industry Standard I.S.1.7, Hardware Locations for Wood Flush Doors. Steel Doors and Frames: Comply with ANSI/DHI A115 series.
 - **Wood Doors:** Comply with ANSI/DHI A115-W series.
 - **Electrified Openings:** Provide steel doors and frames and wood doors prepared to receive electrified hardware connections specified in Door Hardware Sets without additional modification.

3.3. Installation

- 3.3.1. Install each hardware item per manufacturer's instructions and recommendations. Do not install surface mounted items until finishes have been completed.
- 3.3.2. Coordinate electric strike frame prep with security contractor/Installer and door and frame suppliers as required to ensure proper electric strike fit and finish.
- 3.3.3. **The Substrate:** Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.
- 3.3.4. Conform to local governing agency security ordinance.
- 3.3.5. **ADA Standard:** Conform to ANSI A117.1 for positioning requirements for disabled.

- 3.3.6.** Install all thresholds in a continuous bed of Polyurethane or Butyl rubber calk. Have the contractor verify a continuous seal at the exterior of the building before squeeze out is removed.
- 3.3.7.** Installed hardware using the manufacturers fasteners provided. Drill and tap all screw holes located in metallic materials. Do not use “Rive-Nuts” or similar products. Mounting Heights: Mount door hardware units at heights indicated in following applicable publications, unless specifically indicated or required to comply with governing regulations:
 - 3.3.7.1. Standard Steel Doors and Frames:** DHI’s “Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames.
 - 3.3.7.2. Custom Steel Doors and Frames:** DHI’s “Recommended Locations for Builders’ Hardware for Custom Steel Doors and Frames.”
 - 3.3.7.3. Wood Doors:** DHI WDHS.3, “Recommended Locations for Architectural Hardware for Wood Flush Doors.”
- 3.3.8.** Provide and coordinate concealed wood blocking for wall mount stops as detailed in Door Hardware Schedule.

3.4. Field Quality Control and Final Adjustment:

- 3.4.1. Contractor/Installers, Field Services:** After installation is complete, contractor will inspect completed door openings on site to verify installation of hardware is complete and properly adjusted, in accordance with both the Contract Documents and final shop drawings.
- 3.4.2.** Check and adjust closers to ensure proper operation.
 - 3.4.2.1.** Adjust closer to complete full closing cycle in less than 4 to 6 seconds without abrupt change of speed between “Sweep” and “Latch” speeds.
 - 3.4.2.2.** Adjust “Back check” according to manufacturer’s instructions.
 - 3.4.2.3.** Set exterior doors closers to have 8.5 pounds maximum pressure to open, interior non-rated at 5 pounds, rated openings at 12 pounds.
- 3.4.3.** Check latch set, lockset, and exit devices are properly installed and adjusted to ensure proper operation.
 - 3.4.2.4.** Verify levers are free from binding.
 - 3.4.3.1.** Ensure latch bolts and dead bolts are engaged into strike and hardware is functioning.
- 3.4.4.** Report findings, in writing, to Designer and hardware supplier outlining corrective actions and recommendations.

3.5. Schedule of Finish Hardware

3.5.1. Manufacturer’s Abbreviations:

Full name	Abbreviation
Stanley	ST
Best Access Solutions	BE
Precision Hardware	PR
Rockwood Manufacturing	RO

**HOUSTON AIRPORT SYSTEM
DESIGN STANDARDS MANUAL
2023 Edition**



National Guard Products by other suppliers	NG
Folger Adam Security Inc	FA
Adams Rite Manufacturing	AR
Rixon	RI
HES	HS
Trine	TR
Von Duprin	VD

3.5.2. Hardware Sets: (Hardware sets to follow with Opening list)

43- CATHODIC PROTECTION



43 - Cathodic Protection

Part 1 – General

1.1. Overview

- 1.1.1. Impressed current systems will consist of transformer-rectifier power sources, anodes placed in suitable backfill, and appropriate wiring to connect the rectifier(s) to the structures and the anodes. A complete, coordinated system must be provided.
- 1.1.2. All buried, pressurized, or immersed ferrous metal piping systems (except pre-insulated pipe) will be properly coated, electrically isolated, bonded if necessary, and cathodically protected to prevent electrolytic corrosion.
- 1.1.3. Impressed current anodes will be located to minimize stray current effects on unprotected or foreign metal structures. Care will be taken to not place impressed current anodes near pre-stressed concrete pipe or reinforced concrete pipe, which could be damaged by excessive levels of cathodic protection current.

1.2. Quality Assurance

- 1.2.1. **Ferrous Metals:** National Association of Corrosion Engineers (NACE) Standard RP 01 69-92 will be used to determine protective potentials for ferrous metals. While these Standard lists three primary criteria as acceptable, HAS has selected only one that will meet their requirements.
- 1.2.2. The method selected for determining a protective potential will be as follows:
 - 1.2.2.1. A negative polarized potential (immediate off potential) of at least 850 millivolts, relative to a saturated copper-copper sulfate reference electrode.
 - 1.2.2.2. Soil contact points (pavement inserts) over ferrous structures such as welded pipelines, valves, and fittings will be placed at intervals of 50 feet in areas where concrete or asphalt pavements prevent direct contact with the soil. If necessary, a more definitive spacing will be determined on an individual basis by a Corrosion Engineer, where external factors that have an adverse influence on the line. Soil contact points will be a molded polyethylene pavement insert 1¾ inches in diameter by 6 inches long.
 - 1.2.2.3. Where temporary placement of a reference electrode in soil directly over the structure is not possible, a copper-copper sulfate permanent reference electrode will be considered for installation.
 - 1.2.2.4. Coordination tests will be carried out through local committees where they exist. These groups, representing all concerned area utilities and industries, coordinate testing and arbitrate solutions as required. As a rule, the organization owning a current source is responsible for the expenditures necessary for correction of a problem that it creates.

1.3. Shop Drawings and Submittals

- 1.3.1. The selection of the cathodic protection system, to be employed, will be specified by a Corrosion Engineer following preparation of preliminary piping layout drawings. Such selection will be reviewed by HAS for approval.

Part 2 – Products

2.1. Information

- 2.1.1. The rectifier(s) selection will be based on the field survey data and design calculations performed by a Corrosion Engineer during the design stage of the project. The rectifier will be selected to operate at efficient settings but will provide a surplus capacity for reasonable future expansion. As a minimum, provide at least 20 percent surplus capacity for protected structures.
- 2.1.2. The rectifier will contain internal circuit breakers, an output ammeter and voltmeter, and will be mounted in a suitable cabinet or enclosure.
- 2.1.3. All rectifiers will be provided with a properly sized, National Electrical Manufacturers Association (NEMA) 3R rated Advisory Circular (AC) service breaker, which will be placed in proximity to the rectifier.
- 2.1.4. Impressed current anodes will consist of either high silicon, chromium-bearing cast iron, or linseed oil treated graphite, complete with high molecular weight polyethylene lead wires installed with the cable-to-anode connection properly sealed or encapsulated by the anode manufacturer.
- 2.1.5. Specialty anodes will be approved by a Corrosion Engineer if conditions require their use.
- 2.1.6. **Ground Beds:** Anodes are installed in drilled, augured, or trenched holes at depths commensurate with soil resistivity, water tables, and the structure geometry. Anode holes will be filled with the required quantity of a well compacted granular, low resistance coke breeze backfill, as specified, to uniformly surround the anode.
- 2.1.7. Where the ground bed is to be installed under concrete or asphalt, the anode holes will be vented to permit the release of gas generated at the anode surface. Backfill above the coke breeze will consist of pea gravel to assist in venting of generated gases and to permit percolation of water.
- 2.1.8. Galvanic anodes will be installed at all isolated fittings, such as 45 degree, 90 degree, tees, gate valves and fire hydrants, clusters of up to four isolated fittings located within 10 feet of each other, short piping sections, small, well-coated structures, and in areas where interference with other structures might result from the use of impressed current systems. The anodes will consist of galvanized steel cored, magnesium, or zinc rods packed in cloth bags containing a specially prepared backfill material.
- 2.1.9. Non-Ferrous Metals: Protective potentials for nonferrous metals will be established by a Corrosion Engineer and will be in accordance with NACE Standard RP 01 69-92.
- 2.1.10. Direct Current (DC) will be supplied by a suitable transformer - rectifier power supply located adjacent to the tank. The rectifier will be either a constant current, constant potential, or 100 percent manually controlled unit, at the option of a Corrosion Engineer. Manually adjusted rectifiers are the least expensive to install, operate, and maintain. Manually adjusted rectifiers will be specified unless special conditions dictate otherwise.
- 2.1.11. A permanent copper-copper sulfate reference electrode(s) will be installed close to the wall of the tank, between anode strings, for monitoring purposes.
- 2.1.12. The anodes will be suspended from roof mounted fiberglass deck mounts, designed so that the anodes may be inspected or replaced without entering or draining the tank.
- 2.1.13. **Bottom Exterior:** Tanks must be set on self-draining concrete or asphalt pads. If this is not done, external tank bottoms will be sandblasted and coated with an approved coating system, and provisions will be made to apply cathodic protection. All tanks

not set on self-draining concrete or asphalt pads, will have a minimum of one permanent reference electrode installed beneath the center of the tank.

- 2.1.14.** When tanks are to be located on properly drained pads, one coat of an approved inorganic zinc coating will be applied to the externally sandblasted surface prior to erection. The dry film coating thickness range will be from 2.5 to 4.0 mils. Otherwise, cathodic protection will be provided for the external tank bottom.
- 2.1.15. Tank Interior:** The interior of all storage tanks will be sandblasted and protected with an approved protective coating. If the tanks are equipped with floating roofs, the coating system will have sufficient abrasion resistance to withstand movement of the roof.
- 2.1.16. Tank Exterior:** The exterior surface of the tanks will be coated with a coating approved by HAS.
- 2.1.17.** All metallic underground storage tanks (USTs), or fittings, will be coated and cathodically protected or installed in containment piping systems in conformance with local, state, and federal regulations.
- 2.1.18.** Ferrous metal USTs and appurtenances will be coated with a protective coating.
- 2.1.19.** If an approved factory fiberglass cladding system of at least 100 mils thick is applied, no cathodic protection is required. The appurtenances attached thereto will be coated with a compatible coating and cathodically protected.
- 2.1.20.** As an alternate, fiberglass reinforced plastic tanks may be installed. Ferrous metal appurtenances attached thereto will be coated and cathodically protected or installed in containment piping systems. Where submerged turbine pumps are employed, a polarization cell will be installed in the grounding circuit of the electrical power supply.
- 2.1.21.** All direct buried hydraulic elevators or lifts will be coated with a protective coating. The lift will be isolated from all electrical equipment with insulating fittings. Cathodic protection will be applied.
- 2.1.22.** Flush-mounted steel hydrant boxes that are located below grade will be externally protected by a protective coating and cathodically protected. Cathodically protected piping, entering and leaving the box, will be electrically isolated from the hydrant connection. All piping within the box will be bonded together. Cathodic protection will be provided to both the piping and fittings in contact with the soil.
- 2.1.23.** Any steel in buried piles that are directly exposed to the earth will be coated with a nominal 16 mil Discrete Fourier Transform (DFT), single coat coal tar epoxy and cathodically protected if the strength of the full steel cross-section has been used in meeting structural requirements. The steel component of piles, if directly exposed to the soil, will be bonded together by welding a reinforcing bar between all components or by provision of adequate bonding cables.
- 2.1.24.** The test station structure and anode lead wires will be black in color and a No. 12 American Wire Gauge (AWG) stranded copper wire with National Fire Protection Association (NFPA) 70 type thermoplastic, eat and water resistant (THW) or equivalent insulation.
- 2.1.25.** Copper sleeve adapters will be used when thermite welding No. 8, or smaller, wires to structures.
- 2.1.26.** Reference electrode lead wires will be No. 14 AWG stranded copper wire with NFPA 70 type rubber insulated, high heat or water resistant (RHH-RHW) insulation.

2.2. Function

- 2.2.1.** All galvanic anodes will be attached to the structure, requiring protection through the connection of the anode lead wire to a calibrated 0.1-ohm, shunt to one of the structure lead wires that are exothermically welded to the structure. The tops of all galvanic anodes are buried a minimum of 12 inches below the structure, either vertically or horizontally.

- 2.2.2. Where more than one independently cathodically protected structure is in the same area, currents flowing around one structure may affect another. This is particularly true when impressed current systems are used because of their greater operating current capacity and driving voltage. To overcome this problem, two lead wires will be attached to each structure and brought to a surface test station.
- 2.2.3. Care must be taken to insulate DC powered equipment from ground or provide low resistance metallic paths for current return. Provisions will be made in the specification for interference testing by a Corrosion Engineer.

2.3. Serviceability

- 2.3.1. A sufficient number of test lead wires will be installed on ferrous metal structures such as pipelines, so that interference situations can be analyzed and corrected. Cathodic protection interference problems and their solutions are rarely similar, precluding “rigid” or “set” specifications for mitigation. Multiple structures in an area of interference can be very complex, requiring extensive coordinated testing under the direction of a Corrosion Engineer.
- 2.3.2. Test stations will be installed, flush to grade in a concrete slab, at predetermined locations to facilitate inspection of the system. Two test wires will be connected to each buried structure or cluster of fittings by thermal welding and brought to the surface in an appropriate terminal box. All test stations will be filled with clean native soil free of rocks, asphalt, or concrete.
- 2.3.3. When foreign structures are adjacent to protected structures, test wires will be attached to both structures to facilitate interference testing and/or mitigation bonding, if necessary.
- 2.3.4. Above-ground test stations will be specified wherever their use is permissible and will not conflict with aircraft or vehicular traffic. At-grade test stations will be specified in locations where above-ground test stations are not appropriate.
- 2.3.5. **Non-Airport Operations Area (AOA) Test Stations:** All test stations installed that are not in the AOA, will have a lockable cast iron lid with the cast-in legend “CP Test.” A nonmetallic extension tube, minimum length of 18 inches, will be attached to the head of each test station. Provisions will be made for connecting the anode and structure lead wires inside the test station on a non- conductive terminal board.
- 2.3.6. **AOA Test Stations:** Test stations, for installation in the AOA, will be an L-868 Class II ground support light base. The fixture will include an adjustable base that can extend through the concrete and into native soil. The fixture will include a lockable steel lid with the welded legend “CP Test” in 1-inch-high letters.
- 2.3.7. All equipment that may be subject to corrosion, or may require periodic maintenance, will have reasonable access for inspection.

2.4. Durability

- 2.4.1. The airport utilizes both impressed current, and galvanic anode cathodic protection systems (CPS) to supplement coatings used for corrosion control. Impressed CPS will have a design life of greater than 20 years. Maximum design life for galvanic anode systems utilizing magnesium or zinc anodes is greater than 15 years. Cathodic protection systems for immersed service will be designed for a minimum 10 years. In all cases, provisions will be made for replacement of anodes and reference electrodes.
- 2.4.2. Steel water storage tanks will be internally coated and provided with cathodic protection. The design of the cathodic protection system must not be detrimental to the applied coatings in the wetted area of the internal surfaces when the system is properly adjusted. The design life for the cathodic protection anodes will be a minimum of 10 years. Anodes will be installed in the

tank to provide uniform current distribution to all immersed surfaces.

Part 3 – Execution

3.1. Manufacturer

- 3.1.1.** The Contractor will follow codes, standards and the manufacturers recommended techniques when installing CPS. Construction plans, details and specification will be provided to the HAS Project Manager.

44- OPERATIONAL READINESS AND AIRPORT (ORAT)



44 - Operational Readiness and Airport Transfer (ORAT)

Part 1 – General

1.1. Airport Facilities Activation

- 1.1.1. Airport facility activation is the process used to bring a new or redeveloped facility from the state of static completion to normal ongoing operations. Ideally, this happens before and culminates on the opening day.
- 1.1.2. Unfortunately, some facilities open before the airport terminal activation process and/ or even the construction is complete. This may result in an increased potential for delays, diversions, cancellations, and other embarrassments that can lead to significant losses for the airport and its stakeholders.
- 1.1.3. Typically, small facilities with systems, equipment, and procedures everyone is familiar with open without incident and without publicity. The opening of larger more complex facilities with new systems, equipment, and procedures generally receive much more publicity. This is true when the openings are characterized by surprises and delays, diversions, and/or cancellations.
- 1.1.4. Although it appears that the risk of an unsuccessful opening is directly proportional to the size, complexity, and duration of the project, even small poorly planned projects can experience similar problems.
- 1.1.5. The longer the project takes to complete, the larger the facility and the more operational changes needed to operate it effectively, the greater the likelihood that problems will occur. This happens because:
 - 1.1.5.1. Staff working in a facility that is opening may not be adequately familiar with the facility location and type of constructed space (they may get lost or have trouble getting to work).
 - 1.1.5.2. Staff may not be adequately trained on the new systems and operational procedures.
 - 1.1.5.3. New processes, systems, and procedures may not work as anticipated.
 - 1.1.5.4. Construction and systems may not be 100 percent complete and commissioned.

1.2. ORAT at HAS Facilities

- 1.2.1. ORAT is a project method used by HAS to ensure all systems and processes are operationally ready, activated, and responsive to the needs of the users.
- 1.2.2. Airport activation is the process used to mitigate surprises on opening day. This can be achieved by:
 - 1.2.2.1. Confirming that the Contractor has delivered on all contractual obligations and that the new facility is fully commissioned in accord with contract requirements, and fit for purpose.
 - 1.2.2.2. Tracking progress to make sure that the construction team, the activation team, the airport, the airline(s), and all stakeholders are ready and have the processes, staff, skills, training, and tools necessary to effectively operate the new facility.
 - 1.2.2.3. Developing and executing recruiting, training, and familiarization programs necessary to help the airport authority, airline(s), and all stakeholders prepare to operate the new facility.

- 1.2.2.4. Preparing Standard Operation Procedures (SOPs) that address normal, irregular, and emergency processes.
- 1.2.2.5. Managing media and public relations so that expectations are controlled and information is shared in an accurate and timely manner.
- 1.2.3.** Issues associated with operational readiness of facilities that did not deploy an ORAT program are:
 - 1.2.3.1. Concepts and SOPs were not adequately reviewed or developed.
 - 1.2.3.2. Staff was not adequately trained and familiarized.
 - 1.2.3.3. Inefficient communication between design, construction, and operations.
 - 1.2.3.4. Strategy for the shift of operations was developed too late.
 - 1.2.3.5. Lack of adequate time to engage with stakeholders.
 - 1.2.3.6. Operational trials environment was not ready.
- 1.2.4.** ORAT focuses on both the construction process and construction completion stages of a project. ORAT also provides the know-how and professional expertise necessary to execute a successful and on-schedule start of operations, operational readiness, and airport transfer.
- 1.2.5.** When adopted successfully, terminal openings are delivered in a seamless manner without compromising the safety of passengers, aircraft, airport users, and visitors and the employees working within the terminal. Operational risks are identified and evaluated for levels of criticality. Mitigation strategies are developed through contingency planning and validated through a trial and successfully implemented through orientation and familiarization training.
- 1.2.6.** ORAT identifies, and highlights, deficiencies and critical issues regarding the opening of the new terminal infrastructure before they become an issue.
- 1.2.7.** ORAT ensures the smooth, trouble-free, start of operations of a new terminal from day one. The use of ORAT helps guarantee an excellent passenger, and stakeholder, experience starting on opening day.
- 1.2.8.** ORAT detects the changes that are not planned.
- 1.2.9.** ORAT highlights critical issues, proves the functionality of facilities, and systems and the confidence of staff.
- 1.2.10.** ORAT predicts and captures the impact of change.
- 1.2.11.** ORAT highlights the risks related to change.
- 1.2.12.** ORAT allows for the integration of all terminal stakeholders (handling agents, airlines, government authorities and agencies, service providers, vendors, concessionaires, etc.) in the preparation and airport readiness process.
- 1.2.13.** ORAT offers HAS, and its stakeholders, the ability to establish new quality standards and parameters for operations and facility management.
- 1.2.14.** ORAT enables the testing of all systems and facilities, procedures, and personnel under real operational conditions. This allows for a comprehensive analysis of potential problems well in advance of opening day.
- 1.2.15.** The ORAT philosophy is clearly process driven for a good reason. It is one thing to finalize the construction of new airport infrastructure and have it technically completed. To have it operationally ready is a completely different thing.

1.3. Quality Assurance

- 1.3.1.** ORAT encompasses the process used to transition a new or reconditioned airport terminal from a state of contractual completion to full operations. It includes:
 - 1.3.1.1. Confirmation and verification that the facility is fit for its intended use within the terms of the

contract and in association with the ultimate occupiers or users.

- 1.3.1.1.1. Review of new or reconditioned facilities to confirm that they are fit for the intended purpose.
- 1.3.1.1.2. Identification of any issues and determination of whether it is appropriate to address them before or after the opening.
- 1.3.1.2. Development of operating procedures for new or reconditioned facilities, systems, equipment, and business processes.
- 1.3.1.3. Recruiting, familiarization, and training of staff and stakeholders.
- 1.3.1.4. Trials to confirm that the new facilities, operational plans, staff, etc., function and work together as planned.

Part 2 – Products

2.1. Function

2.1.1. A comprehensive ORAT program involves several key activities and phases necessary for a successful activation of a facility. The sequence of activities is as follows:

2.1.1.1. Preparation:

- Stakeholder Management Plan review or development
- Operational concept review or development
- Data Collection
 - Gathering/review of SOPs
 - Gathering/review of key performance indicators (KPIs)-service level agreements (SLAs)
 - Gap analysis of what’s been developed and what has not.

2.1.1.2. Design Construction Interface:

- Operational concepts integrated with the design criteria
- SOPs reviewed and understood by the design team and Project Manager for consideration during the phasing of the project
- Schedule review
- Phasing
 - Operational continuity
 - System installation/commissioning

2.1.1.3. Training:

- Development of test scripts
- Education classes (SOP, Orientation, and Familiarization)
- Trial (Basic, Advanced, and Emergency)
- SOP validation and modification as required

2.1.1.4. Transition:

- Opening of new facility(s)

- Shut-down of old facility

2.1.1.5. **Support:**

- Opening
- Post opening

2.1.2. Prioritize: Understanding what is urgently important and what can wait. The tremendous scope of a terminal project demands an effective prioritization of tasks and their execution.

2.1.2.1. On the one hand this implies, for example, the communication between operations and construction has to be closely managed in order to ensure that most important facilities and systems are sufficiently available and functioning prior to the opening. On the other hand, all operational stakeholders must be carefully aligned to keep everybody on the same page. This requires a well-structured and efficient Stakeholder Management Plan.

2.1.3. Highlight: An ORAT program identifies deficiencies and critical issues regarding the opening of the new terminal infrastructure before they become an issue. The vast experience in ORAT topics and airport operations ensures that the ORAT team knows what to focus on. One key driver is the operational trials; they are a powerful tool to highlight critical issues, prove the functionality of facilities and systems, and the confidence of staff. Furthermore, they establish a platform for all relevant stakeholders to closely work together.

2.1.4. Track: All detected discrepancies have to be reported and continuously followed up. The ORAT team must efficiently track and report critical issues to the higher management and collaborate to identify respective solutions.

2.1.3. ORAT Project Management: Prioritizing, highlighting, focusing, tracking, reporting, and providing feasible solutions are the key tasks of the ORAT program.

2.1.4. Transition: Moving terminal operations from an old facility to a new one is a challenging and complex undertaking, particularly as it involves project phasing. It requires the development of well thought out transition strategies, careful planning, detailed stakeholder alignment, and precise implementation.

2.1.5. Operational continuity is critical, so all elements of the phasing plan need to be completely visible, vetted, and understood at the micro and macro levels to avoid surprises.

2.1.5. After Support: After the transition from old to new facilities, and for the sake of uninterrupted operations, it's important for the ORAT program to provide continued support for a period to ensure systems are operating at their commissioned levels of performance and operation and functional processes are assessed for efficiencies and problematic areas are corrected/improved.

Part 3 – Execution

3.1. Training Program

3.1.1. State of the art facilities and systems are useless if staff do not know how to operate them. Therefore, extensive, specific, effective training, SOPs, orientation, and familiarization are necessary to ensure all stakeholders are confident with the new infrastructure and how they will use it.

3.1.2. Training Program Development: There are four training programs that will be developed, coordinated and provided roles (functions and system involvement/impacts).

3.1.2.1. **Contractor Provided Training:** The Contractor will develop an overall training plan and schedule that will be submitted for review and approval.

- 3.1.2.2. The various installing Contractors will develop individual Operation and Maintenance (O&M) training plans for O&M of their installed systems and equipment.
- 3.1.2.3. O&M manuals, trainer qualifications, agendas and training syllabuses will be submitted for review and approval prior to commencement of training classes.
- 3.1.2.4. Training on systems and equipment will not proceed until the system or equipment is verified and documented to be fully functional.
- 3.1.2.5. **SOP Training:** The applicable stakeholder group will develop or review and revise existing SOPs and develop a training plan on procedures and processes, and schedule for the applicable recipients.
- 3.1.2.6. **Orientation Training:** The ORAT Team will develop an orientation training program and schedule for all stakeholders that need to know about the new facilities.
- 3.1.2.7. **Familiarization Training:** The ORAT Team will develop detailed, in-depth, familiarization training plan and schedule for those who will have “Hands On” opening day and beyond.

3.2. Training Schedules

- 3.2.1. The Activation Team will coordinate with the Commissioning Team to develop a training schedule that includes all types of training listed above. Special attention will be given to trainees’ schedules. Trainees will not be scheduled for more than one training session at a time and sessions will not overlap. The schedule must have flexibility built into it to parallel the progress of construction and associated delays which may come up.
- 3.2.2. Ensure adequate training time for shift workers.
- 3.2.3. The prerequisites, including development of SOPs, KPIs, and SLAs need to be in place prior to commencement of training.

3.3. Trials

- 3.3.1. **Trial Script Development:** There are three types of trials that will be developed and performed.
 - 3.3.1.1. **Basic Trials:** These trials will validate basic knowledge and functionality of system end-users. Trials include adjustment to building systems such as temperature and lighting control plus modification to paging system volume.
 - 3.3.1.2. **Advanced Trials:** These trials will validate facility processes, training and SOP content on issues such as breach of security, lost children and fuel spills.
 - 3.3.1.3. **Emergency Trials:** These trials will validate system functionality, training, SOP content on emergencies such as a stopped elevator with passenger having a heart attack inside. Also, processes such as facility evacuation or heavy smoke in the baggage make-up area.

45- ENVIRONMENTAL



45 – Environmental

Part 1 – General

1.1. Overview

1.1.1. The intent of the Environmental Design Standards is to establish a minimum set of environmental standards for the Houston Airport System (HAS) facility design and construction projects that coordinate and augment the City of Houston (COH) and governing agencies. For other design criteria, please refer to the design submittal procedures, as well as the Jet Fuel, Sanitary Sewer, Drainage, Landside and Airfield Design sections for more information.

Part 2 – Products

2.1. Storm-Water Pollution Prevention Plan

2.1.1. Storm-Water Pollution Prevention Plan: For projects disturbing greater than one acre, a Stormwater Pollution Prevention Plan (SWPPP), including an erosion control plan, must be submitted to HAS along with a signed Notice of Intent (NOI) before a Notice to Proceed will be issued. The NOI is requesting coverage under the Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR150000 to discharge storm-water associated with construction activity or an individual TPDES or National Pollutant Discharge Elimination System (NPDES) permit.

2.1.1.1. Erosion control measures will be designed and implemented to effectively prevent discharge of sediments to the storm drain system and receiving waters. Care will be taken in the design and implementation of such measures to ensure that a safety hazard, such as ponding water on a roadway or airfield, does not occur. Further, water retention attracts birds which pose a hazard to aircraft navigation so no retention can be developed on airport property. Detention areas must discharge water to a dry bottom condition within 24-hours.

2.2. Storm-Water Quality

2.2.1. Storm-Water Quality: All new or renovated facilities must be designed to minimize the impact of storm-water discharges on the environment and assure that the facility can be operated in compliance with environmental laws and regulations.

2.2.1.1. The facility Operator is the company, agency, or entity that will have operational control of daily activities at the facility following the issuance of a Certificate of Occupancy/Use or a company, agency. Additionally, the facility Operator is the company, agency or entity performing work on airport property, including the airfield and landside areas, having control and management of a construction site prior to receiving a contractual Substantial Completion Certificate, such as a Designer or Contractor contracted by HAS for performing work.

2.2.2. As one example, all new or renovated facilities must be designed to eliminate contamination of storm-water, or at a minimum, reduce contamination of storm- water runoff below the TPDES Multi-Sector General Permit No. TXR050000 for storm- water discharges associated with

industrial activity and any subsequent applicable

state regulation, as well as any subsequent applicable federal regulation.

2.2.2.1. Preliminary Actions: To ensure compliance with the above-described objectives, the Operator will submit the following documents to HAS prior to applying for a storm-water quality permit to construct or renovate a facility where there will be a change in storm-water discharge:

- Documents, prepared by the Operator, describing the type and nature of all activities to occur at the site that could potentially impact storm-water quality, runoff velocity, runoff volume or watershed characteristics.
- Documents, prepared by the Operator, detailing the operational controls that will be implemented at the facility. This could possibly be in the form of an operational SWPPP, or the format could be less structured. In any case, the operational measures/restrictions to be employed at the facility must be clearly stated.
- A certification, sealed by the design engineer, stating that “Based upon the above representations made by the Operator, the proposed structural controls will impel storm-water discharged from the facility to meet EPA benchmark standards.”

2.2.2.2. Storm-water Quality Permit: Upon submittal of the three requested documents and approval by HAS, the Operator will satisfy the requirements of these procedures to such extent that HAS will recommend approval of a storm-water quality permit to City of Houston, Department of Public Works and Engineering. The City of Houston Public Works and Engineering Department issues storm-water quality permits, which are issued by the City Engineer for Public Works and Engineering. Additionally, the facility Operator will determine any applicable State or Federal storm-water permits such as a TPDES construction storm-water permit required for construction activity.

2.3. Spill Prevention, Control and Countermeasure Plan

2.3.1. Facilities may be subject to Spill Prevention, Control and Countermeasure (SPCC) regulations at 40 CFR 112. The design of any new or renovated facility must include a submittal by the Operator with a formal determination as to whether an SPCC plan is required; and if so, the design must incorporate the measures specified at 40 CFR 112 or any subsequent applicable federal or state regulation.

Part 3 – Execution

3.1. Post-Construction Procedures

3.1.1. After at least three months of regular operation at the facility, HAS may elect to conduct testing to verify the efficacy of the operational and structural controls. If HAS determines that testing is not necessary, HAS will notify the Operator of this decision, so that a final determination of substantial completion can be made. If HAS elects to conduct testing, HAS personnel will select appropriate pollutant parameters, select a collection event, collect storm-water samples, send the samples out for analysis and provide the results in the form of a Storm-water Quality Report. HAS is committed to ensuring that initial testing and reporting will be completed in less than nine months after the start of regular operations at the facility.

3.1.1.1. Acceptable Test Results: If the testing indicates adherence with all EPA benchmark parameters, HAS will send a notification that no further action is required, and if all other requirements have been satisfied, HAS will issue a final notice of substantial completion.

- 3.1.1.2. Unacceptable Test Results:** If the testing indicates that any EPA benchmark parameter has been exceeded, the project may not be closed out until the Operator has remedied the problem to the satisfaction of HAS. HAS will send correspondence to the Operator when satisfied with the remedies proposed by the Operator. If the Operator has failed to remedy the problem to the satisfaction of HAS within six months after notification thereof, then the facility will be subject to continued monitoring by HAS at the Operator's expense.
- 3.1.1.3. Continued Monitoring at Operator's Expense:** Monitoring will continue until the problem has been remedied to the satisfaction of HAS. Monitoring costs may include labor, supplies, equipment, laboratory charges, and analysis associated with the collection of grab and composite samples from all discharges from the facility. The samples may be analyzed for any pollutants identified in the benchmark standards.
- 3.1.2. Excavated Soil Materials:** Excavated materials must be managed and disposed of in accordance with applicable environmental regulations. Projects that involve subsurface drilling or the excavation, stock piling or movement of soils require a soil management plan that details procedures to be employed to ensure proper handling and disposal. No excavated material or concrete rubble may be removed from any of the Airports without HAS approval. Submit requests through the HAS Project Manager or Representative.
- 3.1.2. Sanitary Sewer Discharges:** Discharges to the Airport Sanitary Sewer System (SSS) will be in accordance with the current legal standards of the Texas Commission on Environmental Quality (TCEQ) or of any governmental body having legal authority to set such standards. Construction Specifications will be taken from "Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic", latest edition, published by the City of Houston's Houston Public Works Department (HPW), except as modified herein. No variance from these specifications or the modifications herein may be made without the approval of the City Engineer for the Houston Airport System (referred to throughout as the City Engineer).
- 3.1.2.1. On-Site Disposal:** Any proposed on-site disposal method such as a septic tank and drain field will be subject to airport approval as well as any and all required county or state health department permit procedures. Any system so approved and permitted will be designed, installed and operated in accordance with the TCEQ "Construction Standards for Private Sewage Facilities."
- 3.1.2.2. Sanitary Sewage Discharge Standard:** Admissible wastes discharge into the SSS is defined herein as admissible discharges. Waste discharges into the SSS that are prohibited, are defined herein as prohibited discharges.
- 3.1.3.3.1. Discharges:** Wastes discharged into the SSS will consist only of wastewater, properly shredded garbage and other wastes that the system is capable of handling, so that: Effluent from the SSS meets the current legal standards of the TCEQ or of any governmental body having legal authority to set standards for such effluents.
- 3.1.3.3.2.** The SSS is not damaged to the extent to cause unnecessary repairs or replacements resulting in increased operation and maintenance expenses.
- 3.1.3.4. Prohibited Discharges:** To enable the highest degree of treatment in the most economical manner possible, and to comply with federal and state regulations, certain solids, liquids and gases are hereby prohibited from entering the SSS in excess of standards as set by federal and state regulations. The prohibited discharges listed below will apply at the points of entry.
- 3.1.3.4.1.** Federal and state regulatory agencies periodically modify standards on prohibited discharges. Therefore, revisions to, additions to, or deletions from the items listed in this section will become necessary to comply with these latest standards.
- 3.1.3.4.2.** No discharge of any of the following will be allowed into the SSS at a point of entry: Storm-water, ground water, roof runoff, sub-surface drainage or water originating from downspouts, yard drains, yard fountain and ponds, or lawn sprays. If the character of the wastewater from any manufacturer or industrial plant, building or other premises is such that it will damage the

SSS or cannot be treated satisfactorily in the SSS, the wastewater will be prevented from entering the SSS.

3.1.3.4.3. No discharge of any of the following substances, materials, waters or wastes will be allowed into the SSS. In addition, it will be unlawful to discharge or cause to be discharged into the SSS any of the substances, materials, waters, or wastes as described in the Houston Texas Code of Ordinance Chapter 47 Article V Section 47-194:

- Any liquid having a temperature higher than 150 degrees Fahrenheit;
- Any water or wastes that contain wax, grease, oil, plastic or any other substance that will solidify or become discernibly viscous at temperatures between 32 to 150 degrees Fahrenheit;
- Any solids, slurries or viscous substances of such character as could cause obstruction to the flow in sewers or other interference with the proper operation of the SSS. Examples include cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, whole blood, paunch manure, hair and fleshlings, entrails, lime residues, slops, chemical residues, paint residues or bulk solids.
- The maximum allowable concentration of suspended solids is 250 milligrams per liter (mg/l), and the biological oxygen demand (BOD) concentration will be less than 250 mg/l;
- Any solids, liquids, or gases that by themselves or by interaction with other substances may cause fire or explosion hazards or in any other way be injurious to persons, property, or the operators of the SSS;
- Any garbage that has not been properly comminuted or shredded;
- Any noxious or malodorous substance which, either singly or by interaction with other substances, can cause objectionable odors, or hazard to life, or forms solids that will cause obstructions to flow, or creates any other condition deleterious to structures or treatment processes, or requires unusual provisions, alteration, or expense to handle such substance. The maximum allowable hydrogen sulfide concentration is 0.1 mg/l;
- Any waters or wastes having a pH less than 6.0 or greater than 10.0 or having any corrosive property capable of causing damage or hazards to structures, equipment, or personnel. of the SSS;
- Any wastes or waters containing suspended or dissolved solids of such character and quantity that unusual attention or expense is required to handle such materials in the SSS;
- Any waters or wastes containing a toxic or poisonous substance, such as plating or heat- treating wastes, in enough quantity to injure or interfere with any wastewater treatment process, to constitute a hazard to humans or animals, or to create any hazard in the receiving waters of the Wastewater Treatment Plant;
- Any wastes or waters exceeding the concentrations listed below:
 - Antimony greater than 0.01 mg/l
 - Arsenic greater than 0.05 mg/l
 - Barium greater than 5.0 mg/l
 - Beryllium greater than 0.01 mg/l
 - Bismuth greater than 0.5 mg/l
 - Boron greater than 1.0 mg/l
 - Cadmium greater than 0.01 mg/l
 - Chromium (hexavalent) greater than 0.05 mg/l
 - Chromium (trivalent) greater than 5.0 mg/l
 - Cobalt greater than 1.0 mg/l

- Copper greater than 1.0 mg/l
- Cyanides greater than 1.0 mg/l
- Fluorides greater than 1.5 mg/l
- Hydrogen Sulfide greater than 0.1 mg/l
- Iron greater than 0.3 mg/l
- Lead greater than 0.1 mg/l
- Manganese greater than 1.0 mg/l
- Mercury greater than 0.005 mg/l
- Molybdenum greater than 1.0 mg/l
- Nickel greater than 1.0 mg/l
- Phenol greater than 0.005 mg/l v.
- Selenium greater than 0.02 mg/l
- Silver greater than 0.1 mg/l
- Tin greater than 1.0 mg/l
- Uranyl ion greater than 5.0 mg/l
- Zinc greater than 5.0 mg/l
- Any free or emulsified oil and grease exceeding, on analysis, an average concentration of 100 mg/l (834 pounds per million gallons) of either, or both, or combinations of free or emulsified oil and grease if it appears probable that such wastes:
 - Can deposit grease or oil in the sewer lines in such manner to clog the sewers;
 - Can overload skimming and grease handling equipment;
 - Not amenable to bacterial action or other treatment processes then being employed by Airport and will, therefore, pass to the receiving waters without being affected by normal wastewater treatment processes;
 - Can have deleterious effects on the treatment process due to excessive quantities.
- Any radioactive wastes greater than the allowable releases as specified by current National Institute of Standards & Technology handbooks dealing with the handling of and release of radioactivity.
- Significant industrial users, as defined by the EPA, will be subject to additional restrictions such as may be promulgated by the HAS, the COH or any of its regulatory Departments.

46- SIGNAGE AND WAYFINDING



46 - Signage and Wayfinding

Part 1 – General

- 1.1.1. INTRODUCTION:** Airports can be complex and difficult spaces to navigate. Numerous factors affect public perception and levels of customer service with the associated airport. This is particularly true when airport modifications or upgrade programs are undertaken. Older terminals and roadways typically have outdated and inconsistent wayfinding signage systems not reflective of current world principles and standards, and improvement projects create even more challenges for individuals functioning within the airport’s wayfinding processes.
- 1.1.2.** As an airport continues to evolve, it is important that its wayfinding and signage systems be designed to accommodate changes in a holistic manner. It must be understood that regardless of an individual facility’s demarcation, the wayfinding pathways extend to and from the surrounding roadways, parking, curbsides, terminals and concourse areas. Facility architecture, services, functions and amenities, as well as vertical and horizontal routes, must always be carefully considered and viewed as part of the airport’s interconnected and overall wayfinding system. A solid understanding of graphic/visual cues and human behavioral responses to wayfinding processes is paramount, and the established wayfinding system must also function seamlessly, within the built environment, without user hesitation or confusion, regardless of what area of the airport is being navigated.
- 1.2.1 BACKGROUND:** Over the next several years, Houston Airport System (HAS) will be implementing major transformations within all their Houston Metropolitan Area airport properties, including George Bush Intercontinental (IAH), William P. Hobby Airport (HOU) and Ellington Field (EFD). These terminals and their associated facilities, as well as their surrounding roadway systems, have been and will be improved and/or expanded, creating continually changing wayfinding conditions.
- 1.2.2** Recognizing the complexity of their redevelopment plans, HAS commissioned a wayfinding program based on a wayfinding analysis and evaluation of the overall existing wayfinding signage programs at all three Houston airport properties. A new holistic and refreshed “HAS Branded” wayfinding signage system was developed. This approved HAS branded wayfinding system will be implemented within all current and future HAS airport property improvement programs.
- 1.2.3** This document presents information regarding the general development and planned implementation of HAS’ new wayfinding signage system within all HAS airport property modernization programs. It will briefly discuss design criteria, how the new wayfinding signage system is to be used, and how it holistically relates to the overall wayfinding program at all HAS properties
- 1.3.1 SCOPE** includes the general design intent, criteria and descriptions for the updated HAS wayfinding signage system as they pertain to implementation within IAH Terminals, Garages, Curbsides and Roadways. This includes:
- Graphic Standards & Guidelines
 - Messages
 - Typography
 - Symbols
 - Arrows
 - Colors

- Wayfinding Signage System & Application
 - Wayfinding Analysis and Application
 - Wayfinding Sign Families

1.3.2 Signs regulated by this document:

- All associated new HAS Pedestrian wayfinding signage (public-use areas only), including directional, identification and informational wayfinding sign types
- All associated new HAS Vehicular wayfinding signage (public-use areas only), including directional, identification and informational wayfinding signs

1.3.3 Signs not regulated by this document:

- Tenant/concession/retail/advertising signs and standards
- Directory map artwork
- FIDS/ BIDS/ CUTE systems
- Life Safety/egress or Regulatory signs
- Egress evacuation map artwork
- Branded Airline elements/ systems/ signs
- Rental car facilities/ areas/ signs
- Non-public, airside/ runway/ exterior or back-of- house areas/ signage

1.4.1 OVERVIEW: Includes general requirements and descriptions of the HAS Wayfinding System. Also includes specific graphic and design criteria/ universal standards applicable to all HAS wayfinding signage:

- Messages & Terminology – including standardized HAS message hierarchy and terminology for each category organized by sign type/message priority (primary, secondary and tertiary).
- Typography – Includes descriptions/ uses of HAS wayfinding typography.
- Symbol Standards – Includes a list of all HAS wayfinding universal symbols
- Arrow Standards – Includes HAS arrow standards, sizes, applications/ meanings, rotation angles and placement.
- Color Standards – Includes all universal color standards as applicable to the overall HAS wayfinding system.
- Sign Family Overview- Includes an organized index of sign types

Part 2 - Governing Bodies, Codes, & Regulations

2.1.1 Governing bodies, codes, city ordinances and standards affecting the HAS wayfinding sign system are outlined in this section. The accompanying lists have been compiled from various entities and codes affecting HAS properties, however, it is not to be considered a complete or final list of requirements.

These lists have been initially established by HAS, and changes will be coordinated with and approved by HAS as required on an individual case-by- case basis. If there is a conflict between a requirement listed here and another authoritative code or standard, the more stringent one shall be applied.

NOTE: This section is for general reference only. It is the responsibility of the Fabricator/Contractor/Installer to always fabricate/engineer/install all signage to meet or exceed all

current applicable local, state and national codes and regulations.

2.2.2 GENERAL REQUIREMENTS:

- An eggshell or satin finish (11 to 19-degree gloss on 60-degree gloss meter) on sign faces and elements is to be used in order to eliminate distracting levels of sheen.
- Letters and numbers on signs shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10.
- Characters and numbers on signs shall be sized according to the viewing distance from which they are to be read unless otherwise noted. The minimum height is measured using a capital letter height and is shown as an “X” for the basis of measurement reference.
- Elements and spaces of accessible facilities which shall be identified by the “International Symbol of Accessibility” are:
 - Parking spaces designated as reserved for individuals with disabilities
 - Accessible passenger loading zones
 - Accessible entrances when not all are accessible (inaccessible entrances shall have directional signs indicating the route to the nearest accessible entrance)
 - When older facilities contain non-accessible elevators and/or restrooms, the accessible elevators and restrooms must be identified as such
 - All other requirements as dictated by local, state and national standards/ building codes and regulations

2.2.2 GOVERNING BODIES: The following list includes (but may not be limited to) the governing bodies and authoritative organizations as applicable to design and engineering at HAS properties:

- AAAE: American Association of Airport Executives
- AASHTO: American Association of State Highway & Transportation Officials
- ACC: Airport Consultants Council
- ADA: Americans with Disabilities Act
- AIGA: American Institute of Graphic Arts
- ANSI: American National Standards Institute
- ASTM: American Society for Testing and Materials
- ATA: Air Transport Association of America
- AWI: Architectural Woodwork Institute
- CAA: Civil Aeronautics Administration
- CAB: Civil Aeronautics Board
- CABO: Council of American Building Officials
- CSI: Construction Specification Institute
- FAA: Federal Aviation Administration
- FHA: Federal Highway Administration
- IATA: International Air Transport Association
- IBC: International Building Code
- LSC: Life Safety Code (written by the NFPA)
- NEC: National Electrical Code (Written by NFPA)
- NEMA: National Electric Manufacturers Association
- NFPA: National Fire Protection Association

- SPC: Standard Plumbing Code (written by the NFPA)
- SBCCI: Standard Building Code
- TDLR: Texas Department of Licensing and Regulation
- TMUTCD: Texas Manual of Uniform Traffic Control Devices
- TXDOT: Texas Department of Transportation
- UBC: Uniform Building Code
- Other governing bodies and authoritative organizations as deemed necessary by HAS

PART 3 – WAYFINDING

3.1.1 No information contained within the design intent/ standard documentation or specifications should be construed as engineered elements or used for the purposes of final sign fabrication, specification or installation. The Fabricator/Contractor/Installer is responsible for all final design, engineering, fabrication and material specifications regarding all structural, electrical, mechanical, foundation, installation and material selection/processes, and must be approved by HAS prior to final fabrication/install. In addition:

- All final design, engineering and amount/sizing of structural sign support elements, material types/ thicknesses, dimensions, welds and attachment methods shall be performed and approved by an engineer licensed in the State of Texas to meet or exceed all applicable local, state and national codes, standards and regulations. Where a conflict occurs between the intent documentation/ specifications, the more stringent requirements per all codes apply.
- Final engineering, dimensions, materials and fabrication are the responsibility of the Contractor/ Fabricator/Installer, and the Contractor/Fabricator/Installer must ensure the highest quality fit and finish for all components of the completed product. All final detailing and specifications are to be provided by the Contractor/Fabricator/Installer within their final fabrication-ready shop drawings and must be approved by HAS prior to final fabrication and installation.
- Wherever dissimilar metals or possibly corrosive installation surfaces are in contact, always separate contact surfaces prior to assembly or installation with the necessary protective coatings/gaskets/ washers to prevent galvanic, moisture related and all other types of corrosion.
- Final fabrication methods, materials, quality and fit/finish to be reviewed and approved by HAS through prototype reviews and testing prior to final fabrication production run/installation processes.
- Colors shown are for reference only and are subject to the limitations of the printing process and/or variance of electronic screen displays. Refer to color system swatches and/or final finish samples for accurate reference.
- Any discrepancies will be identified, documented, and coordinated with HAS prior to final fabrication and installation.
- Contractor/Fabricator/Installer and coordinated with HAS for final approval.
- All final install locations must be marked and verified in the field for proper structural integrity, adequate line of sight, utilities/property-line/other existing or future interferences, and must be in complete compliance with all local, state and national codes prior to fabrication or installation.
- Adjustments to sign locations shown must be documented by the Contractor/Fabricator/Installer and provided to HAS for final approval.

PART 4 – Graphic Standards & Guidelines


Graphic Conventions

Universal Symbols

- Designed to be visually subordinate to message text
- Dark background field with white symbol artwork and thin field outline to reduce halation (if illuminated or reflective)
- Always used in conjunction with wayfinding message text (supports messaging and assists international travelers)

Message Text

- Uses modern wayfinding typeface: "Clearview" font family
- Is proven effective for wayfinding use (pedestrian and vehicular)
- Uses consistent alignment/justification towards arrow direction
- Uses standard Clearview font family's kerning/tracking (unless otherwise noted)



Arrows

- Modern visuals complement new wayfinding sign's design and graphic features
- Sized for maximizing legibility while complementing messaging without overpowering text/symbols
- Features longer "tail" to better differentiate arrow's shape/direction
- "Crow's foot" shape matches legacy look of existing HAS wayfinding signage arrows

Sign Faces

- Primary face background color is "graphite gray" to establish all sign face backgrounds as visually color-neutral when used with the Branded Color ID Feature
- Sweeping end-curves also visually tie into HAS "global" branding and create a subtle visual "motion" cue to the directional edge of the sign
- Divided face units help visually separate messaging and group them to individual directions



Branded ID Accent Color Feature

- Branded ID color is used as an accent only
- HOU and EFD = color to be neutral "silver/gray" accent color
- IAH = color matches each Terminal's unique Branded ID color (Note: signs in Train system areas are an exception and branded as a unique "yellow" color)
- Watermark graphics are representative of HAS "Global" branding features and mimic globe "latitude/longitude grid lines"
- Sweeping bottom curves also draws eye to the directional end of sign and visually tie into the HAS "Global" branding theme

Branded ID Accent Colors - IAH Terminals:

Terminal A	↑	Destination	→
Terminal B	↑	Destination	→
Terminal C	↑	Destination	→
Terminal D	↑	Destination	→
Terminal E	↑	Destination	→

Branded ID Accent Color - IAH Train Systems:

 Subway (underground) OR  Skyway (elevated train; secured-side)	↑	Destination	→
---	---	-------------	---

NOTE: This color accent band used only within Train station area limits

Terminals:



Parking:





Creates a subtle and abstracted visual connection with established HAS Wayfinding Philosophies:

- Provides safe, efficient and appealing wayfinding at all HAS Airport properties (IAH, HOU, EFD)
- Reinforces HAS as the "Airport Standard of Excellence in the Americas"
- Unifies signage as one holistic wayfinding system (both interior and exterior)
- Shares a consistent and positive "tone-of-voice" at all HAS Airports
- Creates shared "sense of arrival" and "sense of place" at each HAS Airport facility/property

4.1.1 OVERVIEW: It is important to maintain and use a consistent and universally applied set of graphic standards and guidelines when implementing new HAS wayfinding. As such, detailed universal graphic standards and guidelines for the HAS wayfinding are provided throughout this section.

4.2.1 GENERAL DESIGN CONSIDERATIONS: In addition to the detailed and specific graphic standards found in this section, the following list of general design considerations regarding standards and guidelines will also be used by designers when implementing all new and/or updated wayfinding signage within HAS modernization programs:

4.2.2 Consistency and Standards-Based: Consistent visual/graphic presentation across the entire wayfinding system to include:

- Graphics/Colors/Typefaces/Arrows/Symbols
- Shapes/Proportions/Sign Types

- Placement/Orientation & Rotation Philosophy/Decision Points

4.2.3 Sign Types

- Configuration, sizing & placement relative to message priority/function
- Primary destinations = priority overhead
- Secondary destinations = secondary overhead or wall mount
- Tertiary destinations = tertiary wall mount
- Simplicity, de-clutter, less is better

4.2.4 Color Coding and Application

- Sign Background = Neutral “Graphite” or “Charcoal” Gray (PMS 433C)
- Minimizes confusion with branded Terminal ID colors
- Creates neutral backdrop for messaging and symbols
- Least visual impact to other existing airport signage during phases of updating

4.2.5 Multi-Color Discipline

- IAH = branded colors used as Terminal and train-system related identification accents only;
 - Helps to highlight and differentiate terminals and associated parking facilities, as well as inter-terminal train/people-mover systems
 - Limited to a small number of priority areas/functions
- HOU & EFD = accent color used as neutral supplement only
- No other colors may be used for HAS wayfinding signage unless otherwise noted and approved by HAS

4.2.6 Typefaces, Arrows and Symbols “Clearview” font family

- Established as effective for pedestrian and vehicular use
- Variety of styles that apply to vehicular and pedestrian traffic
- Sized / kerned appropriately for predicted viewing distances

4.2.7 Use of modern AIGA and DOT Universal Symbol System

- Reinforces destination text
- Assists international travelers
- Graphic presentation/format of HAS symbols as designed reduces possible halation (aka “edge blurring”) if illuminated

4.2.8 Message Hierarchy: The need for visual continuity among all messages and information of the same hierarchy will help eliminate elements which may interrupt the functional wayfinding process or add confusion. Clear and concise information presented by Primary and Secondary signs/messaging systems ensure efficient passenger circulation. Tertiary signs/messaging must always be coordinated with primary and secondary signs/messaging, as well as interior design features and elements. This tertiary category of signs should also always be visually distinguished from other wayfinding signs. Messages will always be organized and maintained within three distinct and functionally tiered categories: Primary, Secondary and Tertiary (see Figures 4.2.8a thru 4.2.8d for full message hierarchy lists).

- Primary – priority destination point(s). This information shall be the largest and the most visible information on each sign. Primary information includes, but may not be limited to:
 - Exterior direction to and identification of Terminal(s).
 - Exterior direction to major vehicular arteries (i.e. nearby access roads).

- IAH example: interior direction to and identification of multiple Terminals if applicable (i.e. A, B, C, D, E) and inter-terminal transit (i.e. Skyway and Subway trains)
- Interior direction to and identification of Gates.
- Interior direction to and identification of Baggage Claim and Ticketing/Check-In
- Secondary – second destinations (supplemental). This information supplements and reinforces information already conveyed by the primary messages and signs listed above. It usually indicates the auxiliary services and support functions of the facility. Secondary information includes, but may not be limited to:
 - Exterior direction to and identification of Ticketing/Check-In, Baggage Claim, and specific Parking Facilities/Areas
 - Exterior identification of Rental Car Return, Airport Exit, etc.
 - Interior direction to and identification of Elevators and Restrooms.
 - Interior direction to Parking and Ground Transportation.
- Tertiary – auxiliary/ support destinations. Tertiary sign information supplements both the primary and secondary messages, and typically informs visitors of regulations and warnings. All regulatory/safety signs are generally considered to be tertiary within the HAS wayfinding system. Tertiary information includes, but may not be limited to:
 - Exterior and Interior TSA related notification messages.
 - Interior CBP related notification messages.
 - Exterior “No Parking” messages.
 - FAA required warnings, notifications and information.
 - Other messages required by code.

4.2.9 Message Functions

- Directional – Direct to destination point(s). Directional messages are the main source of information enabling wayfinding traffic to choose the proper route to a specific destination point. This process involves selecting the correct destination point, and then determining at which point a change of direction will be required. Properly placed directional signage at decision points in adequate quantities is necessary for rapid movement of passengers, employees and vehicles
- Identification – Identify destination point(s). Identification messages mark specific locations/destinations within a defined area or environment. In addition to these locations, identification messages provide proper public exposure to leased tenant spaces and other spaces as governed by Airport Management.
- Informational – Informational messages typically provide specific, detailed and supplementary wayfinding information to assist in orientation within an unfamiliar and/or complex environment. In addition, informational messaging that is graphic in nature (i.e. directory maps) help with providing precise locations for the user in context to the overall facility and its destinations/amenities/etc.
- Regulatory/ Safety – Describe regulations, warnings, safety and egress related requirements - Regulatory/Safety messages relate to DPS, FAA, TSA and CBP requirements, as well as other federal, state, and local city codes/regulations. In general, these messages provide travelers with important regulatory information, such as travel advice, warnings and restrictions.
- Interim (aka Temporary) – May be any of the above, but usually used during interim conditions - Temporary messages generally fall into a separate category of messages, that are typically established during the course of fluctuating interim wayfinding conditions due to construction related processes. Temporary signs shall only be used on an interim basis while permanent signs are in the process of fabrication, repair and/or maintenance. Temporary signs are also an excellent way to test new wayfinding elements and locations prior to final fabrication. Note that all temporary messages shall be reviewed and approved by HAS and Airport Management prior to implementation

4.2.10 Message Terminology

Basic Requirements - Terminology, or nomenclature as it applies to airport signage and wayfinding systems, is a standardized set of words, syntax, grammar, spelling, and symbols used to communicate information to the user of the airport. Terminology systems ensure that information is presented in a consistent way, and that the content of this information is always clear and concise. When a term is shown with a corresponding symbol, that term will always appear with its symbol as indicated. Refer to Appendix Volume 5 for the Universal Symbols List

Change Procedures for Terminology - Consistent use of terminology for established messaging within the HAS wayfinding system is always required. All changes to or additions of new terminology shall require coordination, review and approval by HAS.

4.10.11 Foreign Language: Application and Use

- Universal Symbols - Using universal symbols will assist international and non-English speaking travelers with locating airport destinations in a universal manner, while also eliminating the possibility of unintended bias for individual groups and languages. Refer to Appendix Volume 5 for the Universal Symbols List.
- Informational Wayfinding Signage and Supplemental Materials - Accommodating multiple languages on informational wayfinding signage (i.e. directories and information centers), as well as supplemental materials (such as hand-outs and maps) is the recommended and preferred method of providing detailed wayfinding information to the most diverse groups of non-English speaking airport users. Standards and guidelines for this type of information is not covered within this document and is to be coordinated with HAS as applicable and required.
- HOU Overhead Directional Wayfinding Signage at Primary Decision Points - HAS requires that all priority overhead directionals located at primary decision points within IAH will need to include a set of supplemental Spanish translated destinations for each English destination listed (see Figure 4.10.11 for translations as provided by HAS).
Spanish translations on overhead signage will always be located directly below their associated English destinations and will always appear smaller/ visually secondary to the primary English text. Each group of English and Spanish text for a destination will share a large universal symbol.
- Foreign Language Translations - Foreign language translations, if shown within this document, are placeholders only. All foreign language translations that are used within the HAS wayfinding system are to be provided by professional translators and will be coordinated with HAS staff for final approval prior to final fabrication and installation. All foreign language translations will use the most common and universal dialect for each individual foreign language as deemed appropriate by professional translators and shall be coordinated with HAS staff for final approval prior to final fabrication and installation.

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MESSAGE HIERARCHY - HAS Terminals / Concourses / CBP Areas

PRIMARY	SECONDARY	TERTIARY	REGULATORY/STATUTORY
<p>Directional</p> <ul style="list-style-type: none"> - Terminal X (IAH only: 'X' = terminal letter) - Terminal X via Walkway (IAH only: 'X' = terminal letter) - Skyway to: XXXXX (IAH only: 'X' = ABCDE per terminal area) - Subway to: XXXXX Marriott (IAH only: 'X' = ABCDE per terminal area) - Ticketing/Check-in - Baggage Claim - Ground Transportation - Parking X (IAH only: 'X' = terminal letter) - Red Garage (HOU only: = Existing); Blue Garage (HOU only: = New) - ecopark (Ecopark = HOU only) - Gates X#-X# (IAH: 'X' = terminal ltr.; '#' = gate no.) - Gates #-# (HOU: '#' = gate no.) - All Gates (HOU and EFD only) - X Gates (IAH only: 'X' = terminal letter) <p>CBP Areas (Special Required Directional Messages):</p> <ul style="list-style-type: none"> - U.S. Customs and Border Protection (NOTE: must always be accompanied by the official CBP seal on left side of text; "and" must always be spelled out, no ampersands allowed) - Global Entry - CBP Secondary Area - CBP Exit - Baggage Re-Check 	<p>Directional</p> <ul style="list-style-type: none"> - Skyway to: XXXXX (IAH only: 'X' = ABCDE per terminal area) - Subway to: XXXXX Marriott (IAH only: 'X' = ABCDE per terminal area) - International Departures - International Arrivals - Domestic Flights - Parking - Connecting Flights - Airline Clubs (i.e. Presidents Club, etc) <p>General:</p> <ul style="list-style-type: none"> - Restrooms - Elevators - Elevator 	<p>Directional</p> <ul style="list-style-type: none"> - Telephones - ATM 	<p>All required CBP, TSA & FAA related regulatory/statutory information, including (but may not be limited to):</p> <ul style="list-style-type: none"> - U.S. CUSTOMS AND BORDER PROTECTION SECURITY AREA... - ILLEGAL DRUGS... - ASSAULTING AN OFFICER OR EMPLOYEE OF THE UNITED STATES... - SEARCH AND DETENTION OF PERSONS, BAGGAGE, VEHICLES AND CONVEYANCES... - CURRENCY AND MONETARY INSTRUMENTS... - SMUGGLING... - AGRICULTURAL DECLARATION... - EXPLOSIVES, FIREARMS, AND WEAPONS ARE PROHIBITED... - CURRENCY AND MONETARY INSTRUMENTS... - Etc... <p>Notifications:</p> <ul style="list-style-type: none"> - AUTHORIZED PERSONNEL ONLY - DO NOT ENTER - Warning: Restricted Area, Do Not Enter - Warning: Emergency Exit Only, Door Monitored by Alarm - Etc... <p>Other / General:</p> <ul style="list-style-type: none"> - No Smoking - All life safety/egress - Elevator escape route maps/notifications (with ADA code compliance)
<p>Identification</p> <ul style="list-style-type: none"> - Terminal X (IAH only: 'X' = terminal letter) - Airline Names - All Gates - Gates X#-X# (IAH: 'X' = terminal ltr.; '#' = gate no.) - Gate X# (IAH: 'X' = terminal ltr.; '#' = gate no.) - Gate #-# (HOU: '#' = gate no.) - Baggage Claim - Ticketing/Check-in - Parking X (IAH only: 'X' = terminal letter) - Red Garage; Blue Garage (HOU only) - ecopark - Curbside Bag Check - Bag carousel numbers (i.e. 1, 2, 3, etc) - Self-Service Check-in <p>CBP Areas (Special Required ID Messages):</p> <ul style="list-style-type: none"> - U.S. Customs and Border Protection (NOTE: must always be accompanied by the official CBP seal on left side of text) - Welcome to the United States - Global Entry - CBP Secondary Area - CBP Exit - Baggage Re-Check 	<p>Identification</p> <ul style="list-style-type: none"> - Skyway XXXXX (IAH only: = secured side train; 'X' = ABCDE per area) - Subway to: XXXXX Marriott (IAH only: 'X' = ABCDE per terminal area) - Restrooms - Men - Women - Assisted - Information - Level # (i.e. at elevators = 1, 2, 3, etc) - Elevators - Elevator - Baggage Services - Stair # ('#' = stair no. per individual bag numbering system) 	<p>Identification</p> <ul style="list-style-type: none"> - Oversize Baggage - Baggage Re-Check - Telephones - Emergency Phone - Paging Phone - Fire Extinguisher - AED - ATM - Concessions - Baggage Services - General room name/number IDs (with ADA code compliance) 	
<p>Informational</p> <ul style="list-style-type: none"> - FIDS - BIDS - GIDS - Self-service check-in kiosks information <p>CBP Areas (Special Required Notification Messages):</p> <ul style="list-style-type: none"> - Please Have Your Documents Completed and Ready to Present to an Officer - Thank You for Your Cooperation 	<p>Informational</p> <ul style="list-style-type: none"> - Information - Terminal X Directory (IAH only: 'X' = terminal letter) - Airport Directory - General baggage carousel information - Clocks - Visual Paging 	<p>Informational</p> <ul style="list-style-type: none"> - General - All general safety related information 	<p>NOTE: This message/terminology list is the most recent at the time of this document's publication; message/terminology may be expanded and/or change depending on the unique needs, design conditions & requirements of individual HAS wayfinding modernization programs during design development processes. Always verify and obtain the most recent HAS messaging and terminology list prior to any final design or message specification</p>

Figure 4.2.8a

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MESSAGE HIERARCHY - HAS Curbside / Ground Transportation

PRIMARY	SECONDARY	TERTIARY	REGULATORY/STATUTORY
<p>Vehicular Overhead Directional</p> <ul style="list-style-type: none"> - Commercial Vehicles Only - Passenger Pick-up - Passenger Drop-off <p>Pedestrian Directional</p> <ul style="list-style-type: none"> - Terminal - Baggage Claim - Ticketing/Check-In - Ground Transportation - Passenger Pick-Up - Rental Car - Rental Car Shuttles - Taxis - Buses/Limos/Shared - Hotel/Motel Shuttles - METRO Buses - Limos - Shared Ride Shuttles - Off-Airport Parking - Red Garage (HOU only) - Blue Garage (HOU only) - Ecopark (HOU only) 	<p>Vehicular Overhead Directional</p> <ul style="list-style-type: none"> - *X Only (*X* = Ground Trans. type): - Rental Car Shuttles Only - Buses Only - Taxis Only - Limos Only - Shared Ride Shuttles Only <p>Pedestrian Directional</p> <ul style="list-style-type: none"> - International Departures - International Arrivals - Elevators 	<p>Pedestrian Directional</p> <ul style="list-style-type: none"> - Telephones - ATM - Information - Designated Smoking Area(s) 	<p>All required TSA & FAA related regulatory/statutory information, including (but may not be limited to):</p> <ul style="list-style-type: none"> - U.S. CUSTOMS AND BORDER PROTECTION SECURITY AREA... - ILLEGAL DRUGS... - ASSAULTING AN OFFICER OR EMPLOYEE OF THE UNITED STATES... - SEARCH AND DETENTION OF PERSONS, BAGGAGE, VEHICLES AND CONVEYANCES... - CURRENCY AND MONETARY INSTRUMENTS... - SMUGGLING... - AGRICULTURAL DECLARATION... - EXPLOSIVES, FIREARMS, AND WEAPONS ARE PROHIBITED... - CURRENCY AND MONETARY INSTRUMENTS... - Etc... <p>Notifications:</p> <ul style="list-style-type: none"> - AUTHORIZED PERSONNEL ONLY - DO NOT ENTER - Warning: Restricted Area, Do Not Enter - Warning: Emergency Exit Only, Door Monitored by Alarm - Etc... <p>Other / General:</p> <ul style="list-style-type: none"> - No Smoking - All life safety/egress
<p>Identification</p> <ul style="list-style-type: none"> - Terminal X (used only at IAH: *X* = terminal letter) - Airline Names - X Domestic Flights (used only at IAH: *X* = terminal letter) - D International Departures (used only at IAH) - E International Departures (used only at IAH) - E International Arrivals (used only at IAH) - Curbside Bag Check - Ground Transportation Zones - Zone X (*X* = G.T. zone number) - Terminal - Ground Transportation - Passenger Pick-Up - Rental Car - Rental Car Shuttles - Taxis - Buses/Limos/Shared - Hotel/Motel Shuttles - METRO Buses - Limos - Shared Ride Shuttles - Off-Airport Parking - Red Garage (HOU only) - Blue Garage (HOU only) - Ecopark (HOU only) 	<p>Identification</p> <ul style="list-style-type: none"> - Terminal - Baggage Claim - Ticketing/Check-In - Meeting Place/Passenger Pick-up Numbers - Restrooms - Men - Women - Assisted - Information - Level # (i.e. at elevators = 1, 2, 3, etc) - Elevators - Elevator - Baggage Services - Stair # (*#* = stair no. per individual bldg numbering system) - Information 	<p>Identification</p> <ul style="list-style-type: none"> - Oversee Baggage - Baggage Re-Check - Terminal Door Numbers - Telephones - Emergency Phone - Paging Phone - Fire Extinguisher - AED - ATM - General room name/number IDs (with ADA code compliance) - Designated Smoking Area(s) 	
<p>Informational</p> <ul style="list-style-type: none"> - Ground Transportation Directory - Airport Directory - Terminal Directory 	<p>Informational</p> <ul style="list-style-type: none"> - FIDS (Flight information display system) - CUTE systems 	<p>Informational</p> <p>General:</p> <ul style="list-style-type: none"> - All general safety related information 	<div style="border: 1px solid red; padding: 5px;"> <p><small>NOTE: This message/terminology list is the most recent at the time of this document's publication; message/terminology may be expanded and/or change depending on the unique needs, design conditions & requirements of individual HAS wayfinding modernization programs during design development processes. Always verify and obtain the most recent HAS messaging and terminology list prior to any final design or message specification.</small></p> </div>

Figure 4.2.8b

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MESSAGE HIERARCHY - HAS Parking

PRIMARY	SECONDARY	TERTIARY	REGULATORY/STATUTORY
Vehicular Directional - Parking - Exit - Parking X (used only at IAH: "X" = terminal letter) - Red Garage; Blue Garage (used only at HOU) - Additional Parking - Return to Parking - Level X; Levels X-X ("X" = garage level numbers) - Exit: Credit Cards - Exit: Cashier	Vehicular Directional - Terminal X (used only at IAH: "X" = terminal letter) - X Arrivals (used only at IAH: "X" = terminal letter) - ecopark (Ecopark = only at HOU) - Return to Parking - High Vehicles - Upper Levels - KEEP RIGHT (or LEFT) - RAMP DOWN(or UP)	Vehicular Directional - Employees Only	Notifications: - AUTHORIZED PERSONNEL ONLY - DO NOT ENTER - Warning: Restricted Area, Do Not Enter - Warning: Emergency Exit Only, Door Monitored by Alarm - CAUTION: WATCH FOR CROSSING VEHICLES - CLEARANCE: X'-X" ("X" = feet and inches of lowest clearance) - Etc... Other /General: - No Smoking - All life safety/egress - Elevator escape route maps/notifications (with ADA code compliance)
Vehicular Identification - Parking X (used only at IAH: "X" = terminal letter) - Red Garage / Blue Garage (used only at HOU) - Level X ("X" = garage level number)	Vehicular Identification - Level X ("X" = level number) - Exit - Exit: Cashier - Exit: Credit Cards	Vehicular Identification - CAUTION: Crossing Traffic - CAUTION: Clearance... - Employees Only - Restricted Areas - Reserved Parking	
Pedestrian Directional - Terminal(s) X (used only at IAH: "X" = terminal letter) - Section X ("X" = section number) - Departures - Arrivals	Pedestrian Directional - Elevators - Stairs	Pedestrian Directional - Use Elevators/Stairs to Level X ("X" = garage level number) - Use Crosswalks - Bridge to....(used only at IAH)	
Pedestrian Identification - Terminal(s) X (used only at IAH: "X" = terminal letter) - A (B, C, D, E) Column ID Bands (used only at IAH) - Parking X (used only at IAH: "X" = terminal letter) - Section X ("X" = section number)	Pedestrian Identification - Elevator(s) - Stairs(s)		
Vehicular Informational - Available Spaces (counts by level) - Parking Rate Information (per Airport and Garage as req'd)	Pedestrian Informational - Directory		

NOTE: This message/terminology list is the most recent at the time of this document's publication; messages/terminology may be expanded and/or change depending on the unique needs, design conditions & requirements of individual HAS wayfinding modernization programs during design development processes; Always verify and obtain the most recent HAS messaging and terminology list prior to any final design or message specification.

Figure 4.2.8c

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MESSAGE HIERARCHY - HAS Roadways

PRIMARY	SECONDARY	TERTIARY	REGULATORY/STATUTORY
Directional Overhead - All Terminals <i>(used only at IAH)</i> - Terminal X <i>(used only at IAH: "X" = terminal letter)</i> - Parking - Rental Car - International Arrivals - International Departures - Domestic Flights	Directional Overhead - X Departures <i>(used only at IAH: "X" = terminal letter)</i> - X Arrivals <i>(used only at IAH: "X" = terminal letter)</i> - Highway / Interstate shields - Hotel <i>(used only at IAH)</i> - Airport Exit - Return to Terminals - Passenger Pick-Up - Passenger Drop-off - Commercial Vehicles Only	Directional Overhead - General Aviation <i>(used only at IAH)</i> - Corporate Aviation <i>(used only at IAH)</i> - Air Cargo Center <i>(used only at IAH)</i> - Central Cargo <i>(used only at IAH)</i> - ecopark <i>(used only at IAH)</i>	All required TSA & FAA related regulatory/statutory information, including (but may not be limited to): - Pedestrian Crosswalk - Security Warning(s) - Authorized Vehicles Only - Do Not Enter - No Parking - No Parking Fire Lane - Tow Away Zone
Directional Roadside - Parking X <i>("X" = terminal letter)</i> - Terminal Parking - Hourly Parking - Economy Parking - Rental Car - Rental Car Return - Cell Phone Waiting Lot - Passenger Pick-Up - Passenger Drop-off	Directional Roadside - Airport Exit - Return to Terminals - Oversize Vehicle Parking - Air Cargo Center <i>(only at IAH); Air Cargo (only at HOU)</i> - General Aviation - General Aviation SOUTH: General Aviation EAST <i>(only at HOU)</i> - Corporate Aviation <i>(only at IAH)</i> - ecopark <i>(Ecopark = only at HOU)</i> - Hotel <i>(used only at IAH)</i>		
Identification - Airport Name - Terminal X <i>(used only at IAH: "X" = terminal letter)</i> - X Domestic Flights <i>(used only at IAH: "X" = terminal letter)</i> - D International Departures <i>(used only at IAH)</i> - E International Departures <i>(used only at IAH)</i> - E International Arrivals <i>(used only at IAH)</i> - Parking X <i>(used only at IAH: "X" = terminal letter)</i>	Identification - Airline Names - X Departures <i>(used only at IAH: "X" = terminal letter)</i> - X Arrivals <i>(used only at IAH: "X" = terminal letter)</i> - Rental Car - Rental Car Return - Oversize Vehicle Parking - ecopark - Cell Phone Waiting Lot <i>(only at IAH);</i> - Airport Cell Phone Lot <i>(only at HOU);</i> - Aircraft Viewing Area <i>(only at HOU)</i>	Identification - Airport Services <i>(used only at IAH)</i> - HAS Administration Bldg <i>(used only at IAH)</i> - H.F.D. Station 92 <i>(used only at IAH)</i> - Misc. Building Addresses - Air Cargo Center <i>(used only at IAH)</i> - General Aviation <i>(used only at IAH)</i> - Corporate Aviation <i>(used only at IAH)</i> - Hotel <i>(used only at IAH)</i> - Hotel Parking <i>(used only at IAH)</i>	
Informational - Dynamic airline info - Dynamic Parking info <ul style="list-style-type: none"> • Open / Closed • Number of spaces per level • Rate information - Dynamic security & safety information - Dynamic Ticketing / Check-In info			

NOTE: This message/terminology list is the most recent at the time of this document's publication; messages/terminology may be expanded and/or change depending on the unique needs, design conditions & requirements of individual HAS wayfinding modernization programs during design development processes; Always verify and obtain the most recent HAS messaging and terminology list prior to any final design or message specification.

Figure 4.2.8d

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MESSAGES - Spanish Translations

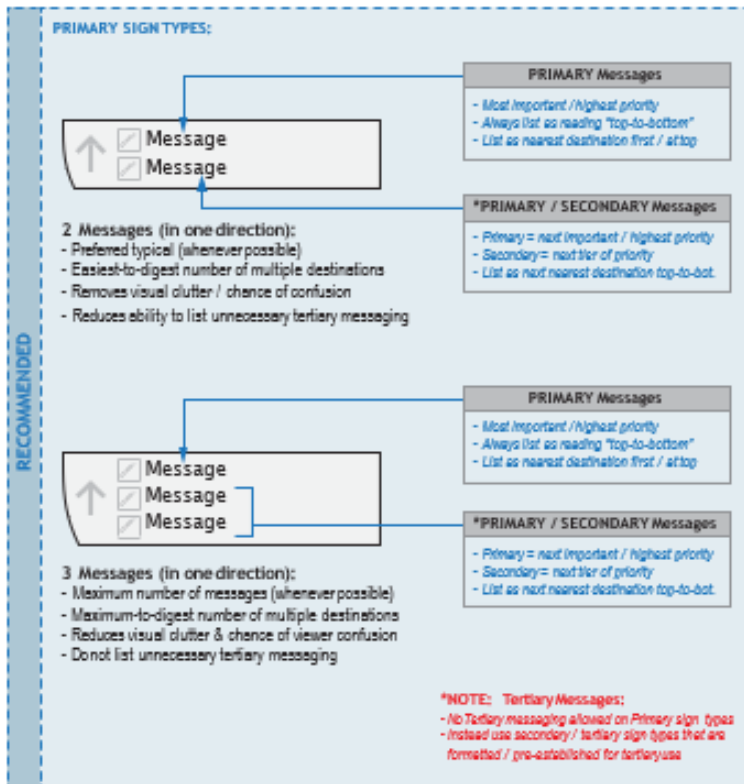
ENGLISH MESSAGE	SPANISH TRANSLATION	
<p>Priority Destinations:</p> <ul style="list-style-type: none"> - Garage - Red Garage - Red Garage: Level 1 - Red Garage: Levels 2-4 - Blue Garage - Ecopark - Ecopark via [symbols] - Ticketing/Check-In - Ticketing: All Other Airlines - Ticketing: Southwest - Baggage Claim - Baggage Services - International Arrivals - Ground Transportation - Rental Car - Passenger Pick-Up - Meeting Place - All Gates - Gates #-# - Elevator - Restrooms - USO <p>Supplemental Text:</p> <ul style="list-style-type: none"> - Use - Use Level 1 Hallway - Use Doors to Elevator Hallway - Use Ticketing Lobby to Bridge - Use Exit to Crosswalk - Use [symbols] to Level 3 Bridge - Use Central Crosswalk 	<p>Priority Destinations:</p> <ul style="list-style-type: none"> - Parqueo - Parqueo Rojo - Parqueo Rojo: Nivel 1 - Parqueo Rojo: Nivel 2-4 - Parqueo Azul - Parqueo Economico - Parqueo Economico por [symbols] - Venta de Boletos - Venta de Boletos: Otras líneas aéreas - Venta de Boletos: Southwest - Reclamo de Equipaje - Servicios de Equipaje - Llegadas Internacionales - Transporte Terreste - Coche de Alquiler - Recogida de Pasajeros - Punto de reunión - Salas - Salas #-# - Elevadores - Baños - No translation needed <p>Supplemental Text:</p> <ul style="list-style-type: none"> - Utilice - Utilice Pasillo Nivel 1 - Utilice Puertas Del Ascensor Pasillo - Utilice Vestibulo de Boletos al Puente - Utilice Salida al Paso de Peatones - Utilice [symbols] al Puente Nivel 3 - Utilice Paso de Peatones Central 	<div style="border: 1px solid red; padding: 5px; margin-top: 20px;"> <p><small>NOTE: This message/terminology list is the most recent at the time of this document's publication; message/terminology may be expanded and/or change depending on the unique needs, design conditions & requirements of individual HAS wayfinding/modernization programs during design development processes; Always verify and obtain the most recent HAS messaging and terminology list prior to any final design or message specification</small></p> </div>

Figure 4.10.11

- 4.3.1 MESSAGE APPLICATION AND RELATIONSHIPS:** Wayfinding messages at HAS airport properties will always be applied in a holistic and consistent manner. This includes the order of how wayfinding messages are listed, as well as the allowable number/quantity of wayfinding messages that are allowed on HAS wayfinding signage.
- 4.3.2 Listing Order -** Most of the domestic and international population read and decipher information in a prioritized “top-to-bottom” organizational format (see Figure 4.3.2). As a result, wayfinding destinations are typically prioritized/listed as:
- The most important destinations or closest in proximity are listed first;
 - i.e. the highest priority and/or closest proximity at the top.
 - Subsequent messages are listed in descending order downward;
 - i.e. the next most important and/or next in order of closest proximity.
- 4.3.3 Number/Quantity of Messages -** Directional messaging, for both pedestrian and vehicular traffic, tends to be overwhelming when more than three messages are used for a single direction on directional signage. Limiting the number/quantity of messages in a single direction is important for rapid deciphering of messaging while maintaining smooth wayfinding circulation flows.
- Note that directional messaging should typically be limited to two messages for a single direction whenever possible, and a maximum of no more than three messages for a single direction. Four messages, although sometimes necessary and will depend on unique wayfinding circumstances, is not preferred and should be limited whenever possible. If four messages are deemed necessary, they should typically be limited to secondary or tertiary messaging/sign types (see Figure 4.3.2).
- 4.4.1 MESSAGE FUNCTION AND HIERARCHY RELATIONSHIPS:** Along with prioritizing wayfinding messages in a hierarchy format (i.e. Primary vs. Secondary vs. Tertiary messages), they will also typically have functional properties associated with them (i.e. general vs. specific). They will also typically determine the categorization of sign type priority (i.e. Primary, Secondary and Tertiary sign types).
- 4.4.2 Message Priority Categorization and Function -** It is important to understand that the same message may fall under a different priority category depending on its use and location within the overall wayfinding system. For example, traffic on a roadway approaching a terminal may find the term “Parking” as a primary message. However, the same term found in the terminal may be considered secondary when compared to other destinations in the terminal facility.
- A message’s function will also typically change from the more general (i.e. “Terminal” or “Ground Transportation”) to the more specific (i.e. “Terminal A” or “Taxi, Shuttles, etc.”) as wayfinding traffic moves through an area/facility and approaches their destinations. Consistently maintaining this same functional use for messages throughout the entire wayfinding system is essential to smooth wayfinding traffic flow and establishes solid visual continuity among messages/ information and the sign system itself.
- 4.4.3 Message Priority and Sign Type Priority -** The relationship between message function and message hierarchy also creates a foundation for the classification and determination of sign types. Message hierarchy (i.e. Primary, Secondary and Tertiary messaging) is used to group messages for their general use on directional, identification and informational sign types, each with their own specific application and usage priorities (i.e. Primary, Secondary and Tertiary sign type classifications).
- 4.4.4 Message Grouping by Priority -** Emphasis should be placed on the reduction of signs and the amount of messaging wherever possible. However, it is typically a given that airport wayfinding sign systems are

complicated with large quantities of varying sign types and associated messaging. As such, grouping messages by priority is necessary, and will result in fewer unique sign and message types.

For example, primary messages should typically be grouped with other primary messages whenever possible. If there is need for secondary messaging on the same sign, its importance will always be secondary to all primary messages. Ultimately, secondary messages may be better used on secondary sign types (if deemed appropriate for a given circumstance/condition or environment).



Not Recommended (however, follow these guidelines if used):

SECONDARY/TERTIARY SIGN TYPES:

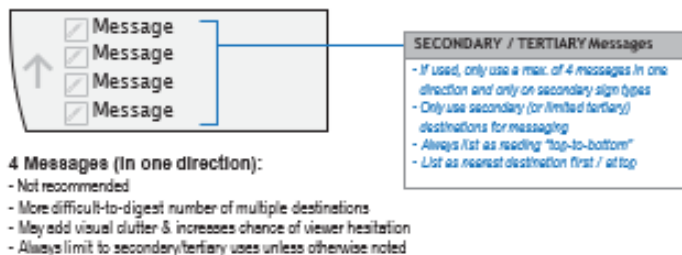


Figure 4.3.2

4.5.1 HAS WAYFINDING: TYPE STYLES: The Clearview font family has been chosen as the standard HAS wayfinding typeface due to its wayfinding efficiency and industry-wide adoption as a typeface that is suitable for use in wayfinding programs. Note that specific Clearview type styles are uniquely associated with Pedestrian and Vehicular related wayfinding audiences. As such, only the following applicable type styles may be used:

- Pedestrian Wayfinding: all text on Pedestrian HAS wayfinding signage shall be set in the following *ClearviewText* and *ClearviewOne* font families, unless otherwise specified (see Figure 1.3.4a):
 - *ClearviewText* Medium = all standard wayfinding word messages
 - *ClearviewOne* Book Condensed = supplemental wayfinding word messages (i.e. “via,” “to:” and CBP notification text)
- Vehicular Wayfinding: all text on Vehicular HAS wayfinding signage shall be set in the following *Clearview Highway* font family, unless otherwise specified (see Figure 1.3.4b):
 - *Clearview Highway* 2-W = all standard word messages (“W” = white text on dark background)
 - *Clearview Highway* 1-W = supplemental wayfinding ID word messages (“W” = white text on dark background)
 - *Clearview Highway* 2-B = all standard word messages (“B” = black text on light background)
 - *Clearview Highway* 1-B = supplemental wayfinding ID word messages (“B” = black text on light background)

4.5.2 Capitalization - Aside from special decorative uses where all-caps is desirable and/or used on specific regulatory related messaging, all word messages shall be in “Title Case.” Title Case is defined as the initial “alpha” letter shown in upper case followed by lower case letters for each individual word in a given message.

Examples of exceptions include (but are not limited to):

- EXIT; EXIT ONLY
- DO NOT ENTER
- ATM
- KEEP LEFT; KEEP RIGHT
- NEXT LEFT; NEXT RIGHT

Other notables regarding message capitalization:

- As required by the Americans with Disabilities Act, all tactile messages shall be in all upper case.
- All vehicular wayfinding signage must meet all requirements as established within MUTCD and TXDOT signage design standards.
- Upper case letters shall have an upper case “X” height as determined by using a capital letter “I” when determining a layout’s text height dimension.
- Lower case letters should have a lower case “x” height that is approximately two-thirds the height of the uppercase letters
- Each word in a message shall be capitalized, except for articles, prepositions and conjunctions (i.e. to, from, via, etc.).
- A consistent capital letter height shall always be maintained when wayfinding signs are used in sequence unless otherwise noted.

4.5.3 Typographic Restrictions - Typefaces or weights not described here shall not be used at HAS airport properties, unless otherwise noted and approved by HAS.

The following additional typographic restrictions shall always apply and be strictly adhered to when designing or specifying signage for HAS airport properties:

- Use only the type styles as specified for a specific traffic type as shown in this document (i.e. Pedestrian vs. Vehicular):
 - Use only Pedestrian type styles on Pedestrian wayfinding signage.
 - Use only Vehicular type styles on Vehicular wayfinding signage.
- Modification of letter shapes is prohibited unless otherwise specified and approved by HAS.
- Condensed, extended, skewed, stretched, outlined or otherwise distorted type shall not be used.

Language to this effect will always be included in the specifications for all related HAS wayfinding signage projects, and variances must be reviewed and approved by HAS.

Type styles specialized for a particular sign face or graphic layout shall be used exactly as specified in wayfinding signage design documents. Deviations from the sign type's application provided in layouts are strictly prohibited. Refer to individual sign types for exact specifications and text sizing/layout details.



Figure 4.5.1a Type Style: Pedestrian Wayfinding Text Example

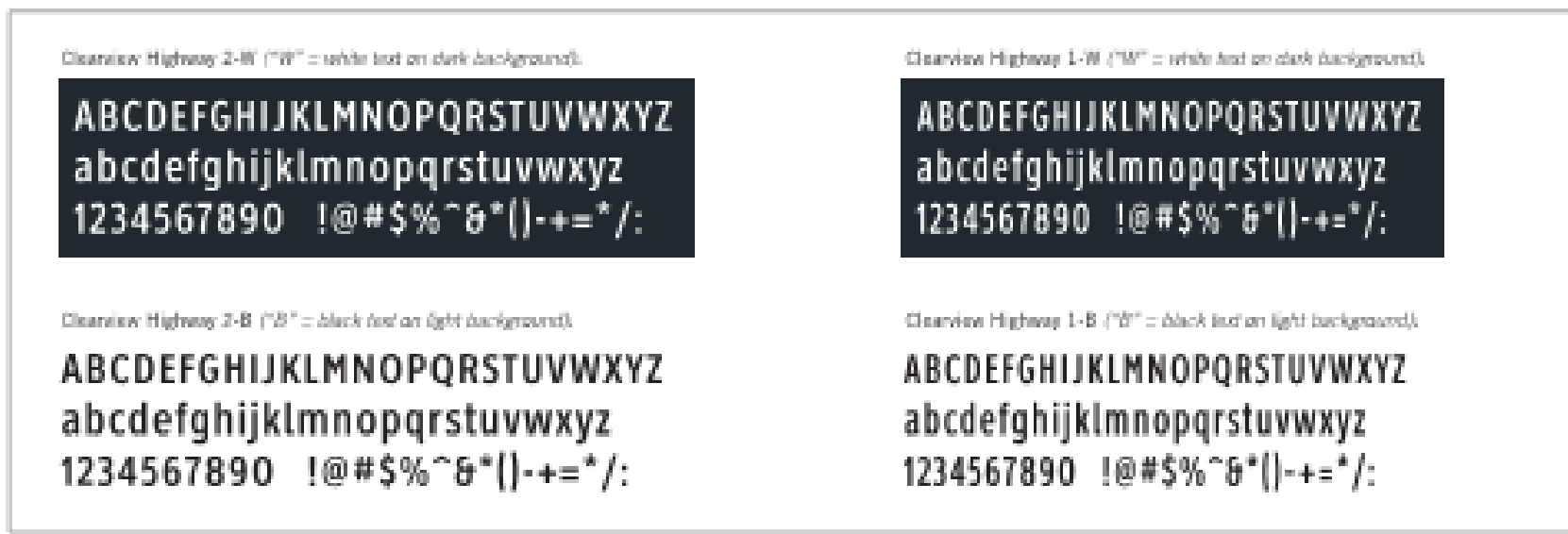


Figure 4.5.1b Type Style: Vehicular Wayfinding Text Example

- 4.6.1** TYPE SPACING/ LETTER SPACING (Kerning and Tracking): Kerning is typically defined as the process of adjusting the spacing between characters in a proportional font, usually to achieve a visually pleasing result within a set of readable text. Also note that while kerning adjusts the individual spacing between individual letter forms, tracking instead adjusts the spacing uniformly over an overall set/range of characters in a word or set of words.

Tracking adjustments are not usually as ideal for readability on wayfinding signage as they tend to make individual words and groups of words more difficult to read, whereas kerning helps to maintain the visual harmony of words.

Unless otherwise indicated, all sign messages shall use the Clearview font family's default letter spacing with regards to kerning and tracking. Messages set according to the typeface maker's letter spacing standards will not normally require adjustment (see Figures 4.6.1a and 4.6.1b). In some circumstances, modification of the spacing between individual letters or lettersets may improve the appearance and legibility of a sign message. Examples of typical needs for kerning adjustments include (but may not be limited to) improved visibility at increased viewing distances, as well as the elimination of unacceptable levels of "halation" (aka visual blurring together of letter strokes/graphic elements) due to internal or external illumination of the sign face.

Designers are required to review sample messages for all sign projects and shall recommend spacing modifications where they can be shown to be advantageous or necessary. In these instances, hand-kerning will be required to adjust spacing and shall be noted as such within the sign's specific layout using a +/- pica unit of measurement as used within professional graphic design software. Other letter spacing restrictions include: reducing normal letter or word spacing (i.e. to fit a lengthy message within a restrictive size layout area) is not acceptable and shall always be avoided; punctuation marks, which relate to two letters, should be spaced equally from both letters.

- 4.6.2** WORD SPACING - Unless otherwise indicated, spacing between words in a message is typically $\frac{3}{4}$ (.75) times the capital letter height (adjust by appropriate percentage if hand-kerning). For example, a message using 4" cap letters will have approximately 3" between words (see Figures 4.6.1a and 4.6.1b).

- 4.6.3** LINE SPACING (Leading) - Leading is typically defined as the distance between the baselines of successive lines of type. Typically, the *spacing between *related* lines of message text (i.e. a message in a layout that must continue to the next line down due to not enough available width on the first line) will typically be approximately $\frac{1}{2}$ (.50) times

the capital letter height (unless otherwise noted). Typically, the *spacing between *unrelated* message text lines (i.e. two completely separate ideas/ destinations/messages) will typically be approximately 1 times the capital letter height (unless otherwise noted).

**NOTE: Always refer to actual HAS wayfinding signage face layouts for all final definitive line spacing requirements per each individual sign type as shown in current HAS wayfinding signage design intent/construction documents.*



Figure 4.6.1a Pedestrian Messages: Typical Type Spacing

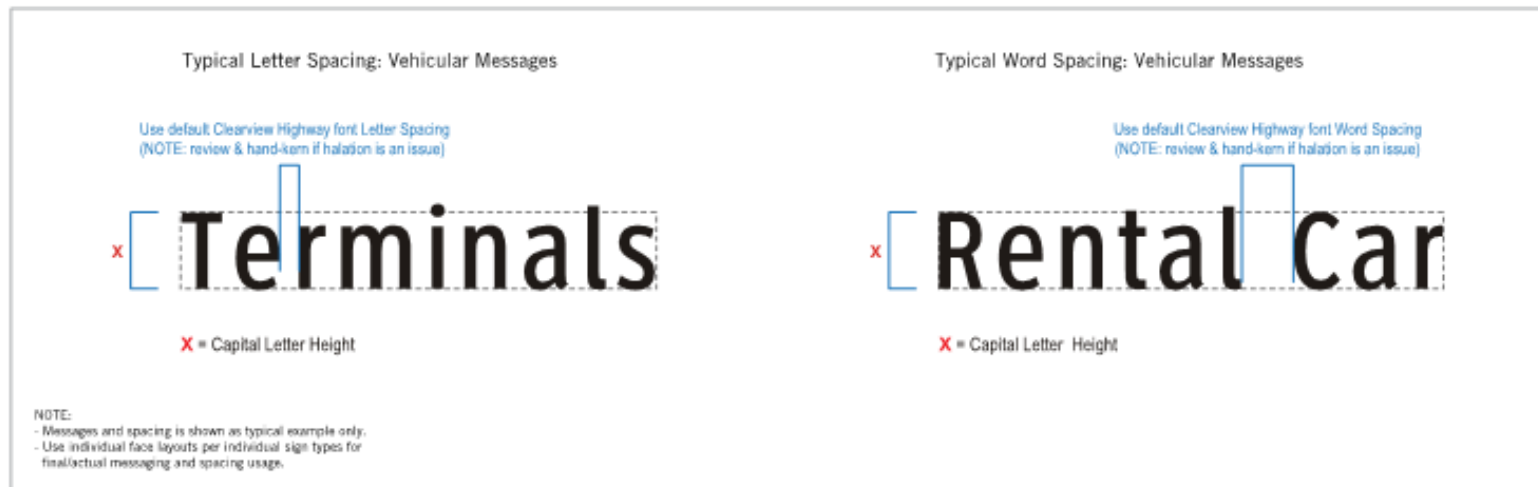


Figure 4.6.1b Vehicular Messages: Typical Type Spacing

4.6.4 LEGIBILITY: Legibility is typically defined as the recognition of various elements that make a message or symbol understandable without the aid of additional wording or pre-conditioning. Additional factors may affect legibility, and include (but may not be limited to):

- Placement
- Lighting
- Contrast
- Viewing angles and distances

These factors must always be considered by designers when developing new or updated wayfinding signage to be implemented at HAS properties

4.6.5 PEDESTRIAN LEGIBILITY: It is necessary to have consistent placement and presentation of messaging on all wayfinding signage that are viewable to pedestrian traffic. This includes the sign's height above finished floor, and the overall size of the sign (including its support structure). This will minimize unintentional misinterpretation of the pathways and uses of the facility when viewing the nearby wayfinding signage.

A pedestrian sign's location will often dictate the range of acceptable visibility to the viewer for them to quickly and effectively interpret the information. If the viewer is given an appropriate distance to comprehend the messaging, hesitation will be reduced, and informed decisions will be made regarding changing direction or continuing the same pathway. In a fast paced (often congested) environment such as an airport, a conservative pedestrian viewing distance of approximately 25 feet to each inch of capital letter height should be used when specifying wayfinding signage (see Figure 4.6.5). However, all text on pedestrian wayfinding signage must always follow all sizing and legibility requirements as established by the latest editions of the ADA and TAS.

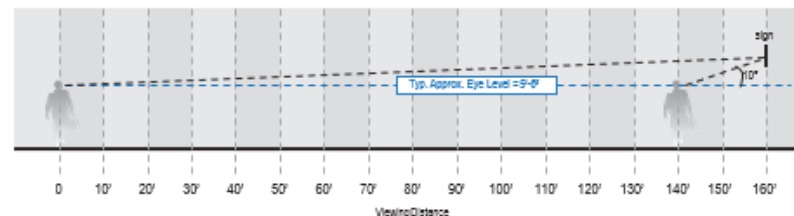
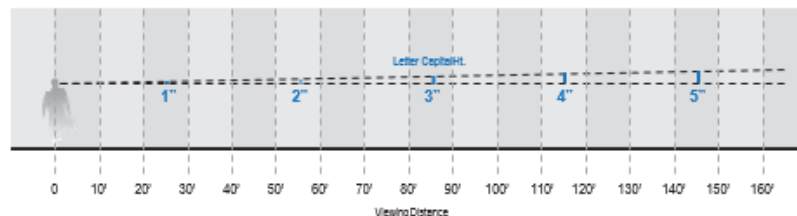
4.6.6 VEHICULAR LEGIBILITY: Similar to pedestrian traffic, it is also imperative to maintain consistent placement and presentation of wayfinding messaging on all signs that are intended to be viewed and used by vehicular traffic. Again, this will minimize unintentional misinterpretation of the pathways and uses of the Airport's roadways, as well as allow drivers ample time to make safe and informed decisions.

There are several factors that affect the legibility of vehicular messages, including (but not limited to) the sign's height above finished grade, lateral spacing from the roadway, number of messages, overall size of the sign (including support structure) and the speed at which a vehicle is traveling. As a result, when designing new or updated vehicular wayfinding signage, *a set of general design guidelines should be used when determining a conceptual reference point for adequate message size (see Figure 4.6.5).

NOTE: The information shown in Figure 4.6.5 is based on typical and generally accepted wayfinding industry standard practices (equations & table provided by the United States Sign Council, USSC), and is only a basic conceptual design reference. These are general "rule-of-thumb" guidelines and should only be used as an initial starting point when determining vehicular wayfinding signage legibility. This information should not be construed as absolute or final. All vehicular wayfinding signage legibility must meet all requirements as established within MUTCD and TXDOT signage design standards

4.6.7 TESTING LEGIBILITY: It is also highly recommended that field testing of 1:1 actual-size prototypes be utilized to determine the maximum effectiveness of a conceptual wayfinding signs legibility per its individual location and line-of-sight conditions within a given area/project. All prototype development and field testing must be coordinated with and approved by HAS. Consistency in Legibility, Consistent sizing of wayfinding message text and symbols from sign-to-sign throughout an airport also adds to the overall effectiveness of the wayfinding system. It establishes a consistent and professional looking display of information, which in turn will allow for much more rapid comprehension of the wayfinding information and general orientation with in an airport's varied and complex environments.

Typical Pedestrian View Distances and Legibility Considerations:



Typical Vehicular View Distances and Legibility Design Guidelines:

Typical Vehicular Sign Legibility Design Formulas:

Source:
USSC Sign Legibility Rules of Thumb, United States Sign Council (latest ed., 2006 shown)

Example Equations

Notes:
LH = Letter Height (upper case letters in inches)
LN = No. of Lanes of Traffic
LO = Lateral Offset (from curb in feet)
LI = USSC Legibility Index (from Table 1)

Example Equation 1:
 $LH = (LN \times 10 + LO) / 5$

Equation 1 Example Solution:
Conditions:
- 2-Lane Roadway
- Lateral Offset = 37 feet from curb
- Letter Style = unknown

$LH = (2 \times 10 + 37) / 5$
 $LH = 57 / 5$
 $LH = 11.4$ inches (upper case letters)

Example Equation 2:
 $LH = (LN \times 10 + LO) / (LI / 6)$

Equation 2 Example Solution:
Conditions:
- 2-Lane Roadway
- Lateral Offset = 37 feet from curb
- Letter Style = Helvetica, all caps
- Light Letters on Dark Background
- USSC Legibility Index = 22 ft / in (from Table 1)

$LH = (2 \times 10 + 37) / (22 / 6)$
 $LH = 57 / 3.67$
 $LH = 15.5$ inches (upper case letters)

Table 1: USSC Standard Legibility Index (from source page 5)

*Illumination	**Letter Style	Letter Color	Background Color	Legibility Index (L/I)	
				Title Case	All Caps
External	Helvetica	Black	White	29	25
External	Helvetica	Yellow	Green	26	22
External	Helvetica	White	Black	26	22
External	Clarendon	Black	White	28	24
External	Clarendon	Yellow	Green	31	26
External	Clarendon	White	Black	24	20
Internal Translucent	Helvetica	Black	White	29	25
Internal Translucent	Helvetica	Yellow	Green	37	31
Internal Translucent	Clarendon	Black	White	31	26
Internal Translucent	Clarendon	Yellow	Green	37	31
Internal Opaque	Helvetica	White	Black	34	29
Internal Opaque	Helvetica	Yellow	Green	37	31
Internal Opaque	Clarendon	White	Black	36	30
Internal Opaque	Clarendon	Yellow	Green	37	28
Neon	Helvetica	Red	Black	29	25
Neon	Helvetica	White	Black	38	32

*NOTE: Illumination Name Variations ("Color") may include:
- External; Internal with Full Translucent Background; Internal w/ Translucent Letters & Opaque background; Exposed Neon Tube

**NOTE: Letter Styles shown are typical examples only:
- Helvetica = a typical example of a sans serif version of a typeface
- Clarendon = a typical example of a serif version of a typeface

How to Use Table 1:
- Determine letter height for given viewing distance
- Select combination for: letter (font) style, illumination, letter color & background color most closely resembling table's listings
- Divide viewing distance (i.e. Viewer Reaction Distance "VRD" in feet) by applicable Legibility Index (aka "LI") value in Table 1
- Result = Capital Letter Height (in inches)

- Example:
VRD = 600ft.
LI = 30
 $600 / 30 = 20'$
Capital Letter Ht. = 20 in.

Typical Driver Focusing Points at Various Speeds:

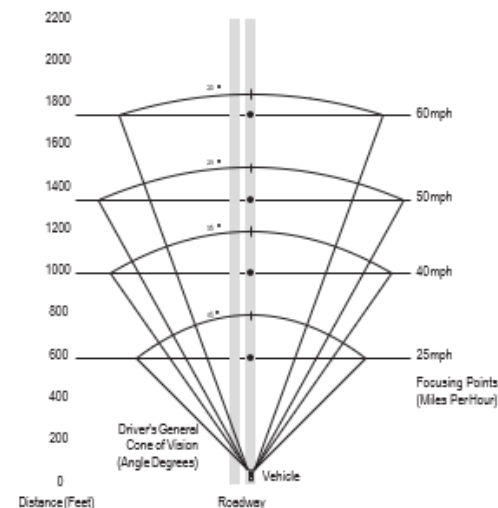


Figure 4.6.5 Typical Wayfinding Industry Accepted Legibility Design Guidelines

4.7.1 UNIVERSAL SYMBOLS: Through a collaborative effort between the Department of Transportation (DOT) and the American Institute of Graphic Arts (AIGA), standard symbol sets were developed for implementation and universal recognition within travel related wayfinding environments. These symbols were developed and selected from this effort for their ability to quickly convey priority messaging, destinations or services to the largest percentage of viewers. Due to also having the ability to convey general ideas of the related text-based messages in a broad/universal manner, these symbols assisted international travelers in understanding the messaging without having to read the local language or add layers of multi- language text. Thus, they are now typically referred to as “universal” symbols within the wayfinding industry.

A cohesive and easily identifiable set of universal symbols is a critical part of a successful wayfinding system. To be most effective, these universal symbols must work in harmony with the wayfinding nomenclature/ terminology and must always be applied with absolute consistency. Universal symbols should also always be used for reinforcement and visual confirmation of wayfinding message text, especially at the pedestrian level, unless otherwise noted.

Note the following philosophies and guidelines that were used in the development the HAS wayfinding system’s symbol set:

4.7.2 Symbols Supplementing Messaging: The use of universal symbols, in tandem with short verbal messages, is more effective than the use of symbols or messages by themselves. However, note that universal symbols should act as a *supplement* to the messaging, rather than serving as the primary graphic or messaging element.

4.7.3 International Traveler Consideration: Accommodating multiple languages on directional signage is costly, impractical and not recommended. Universal symbols can serve as an effective means of assisting international and non-English speaking travelers with locating airport destinations.

4.7.4 Limit Use to Priority Messaging: Mixing universal symbols (and their related message text) for relatively minor or tertiary airport functions/activities/tenants with essential public wayfinding information weakens the overall communication of the wayfinding system.

By limiting their use to priority airport messaging and destinations, universal symbols help to supplement and graphically highlight the importance of the priority messaging.

4.7.5 Less is More: Too many universal symbols, messages or arrows at any one location can be counter-productive to the wayfinding information being provided. An over- abundance of symbol use and messaging in a given direction or at a decision point can result in information overload, which in turn will cause hesitation, confusion and general distrust of the wayfinding system.

4.7.6 Symbol Categorization: Universal symbols have been divided into specific categories based on their function as they are to be used within specific areas of HAS airport areas. These categories include:

- Pedestrian wayfinding signage
 - Public Service Symbols
 - Concessions Symbols
 - Ground Transportation Symbols
 - Terminal and Inter-Terminal Train Symbols
 - Travel Symbols
 - Regulatory Symbols
- Vehicular wayfinding signage:
 - Only certain/select Travel Symbols
 - Terminal ID Symbols

- Highway ID Symbols

- 4.7.7** Regulatory Symbols: Symbol shape, placement and color on all regulatory signs shall conform to the latest editions of the ADA Standard for Accessible Design, local/national building codes, TXDOT Traffic Manual and the Federal Manual on Uniform Traffic Control Devices (MUTCD).
- 4.7.8** Change Procedures and Restrictions for Symbols: To be most effective, a symbol system must allow for the fluctuating nature of modern and continually changing airport related terminology. As such, development of new universal symbol artwork is allowed when deemed necessary and appropriate for a given situation/condition with the understanding that consistent use of HAS universal symbol artwork standards for established messaging is always required. All changes to existing and/or additions of new universal symbols shall require coordination, review and approval by HAS. Universal symbols not approved by HAS as described in this section and/or not illustrated in this document shall not be used.
- 4.7.9** HAS Logo Usage: Use of the HAS logo and/or literal/verbatim applications of the logo's elements within the wayfinding system is not allowed. When the HAS logo is applied in inconsistent, haphazard or inappropriate ways, it weakens the strength of the HAS brand itself, and may result in negative associations with the HAS brand itself, regardless of original intent. It should also be noted that using literal representations of the HAS logo for the purposes of decoration and/or graphic filler on wayfinding signage will create an additional layer of visual clutter that must also be digested within the process of deciphering of wayfinding messaging and information.
- 4.7.10** HAS Universal Symbols: An effective set of universal symbols will always supplement and enhance the messaging rather than graphically overpower it. Universal symbols usage within HAS properties shall always be applied consistently and holistically across the entire airport and will always be applied with their associated messaging unless otherwise noted. Application of HAS universal symbols with no accompanying message text is not unless otherwise noted.

The following is a general description of the graphic elements of HAS universal symbols:

- Symbol Artwork: White
 - Reversing the symbol artwork as white on dark background tones down the presentation of the symbols in relation to the message text and gives it less visual priority.
 - It also reduces the possibility of undesirable levels of halation when illuminated (front reflective or internal).
- Symbol Field Outline: White, thin line with square corners
 - Along with the reduction of halation, utilizing a simple thin outline with square corners around the background field will help to modernize the look of the symbol graphics, while keeping visual harmony with the clean/modern shapes of the HAS wayfinding signage system.
- Background Field: HAS Wayfinding Dark Gray (PMS 433C)
 - Again, utilizing a darker background field behind lighter symbol artwork will reduce the visual impact on the messaging, while reducing the possibility of undesirable levels of halation

Additionally, a basic graphic description of HAS universal symbol artwork elements is provided below in Figure 4.7.10. For a complete listing of HAS universal symbols and their associated messaging, Refer to Appendix Volume 5 for the Universal Symbols List. Artwork available by request

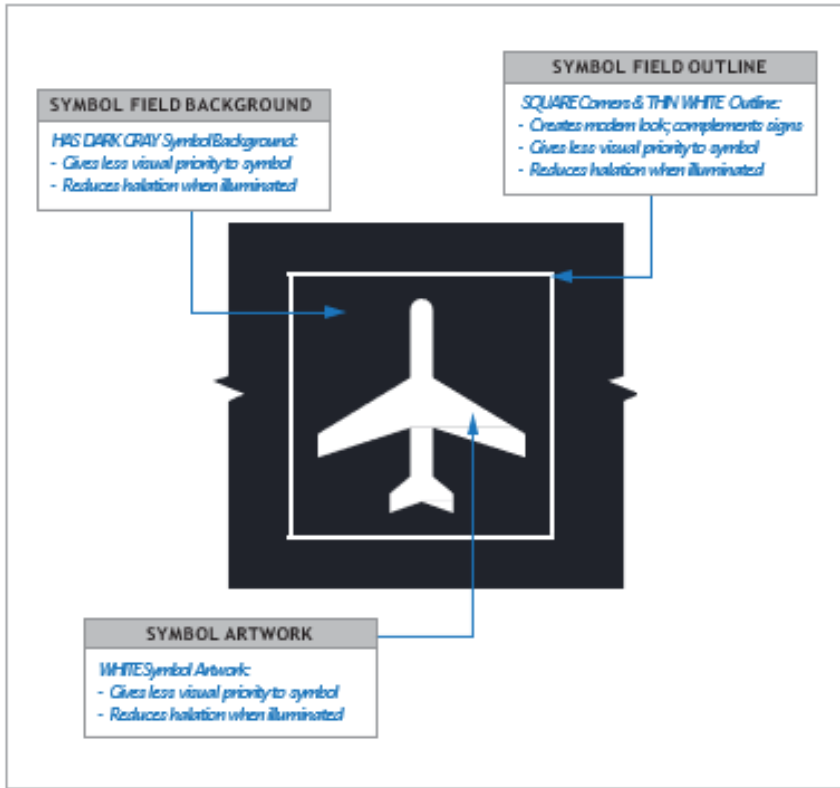
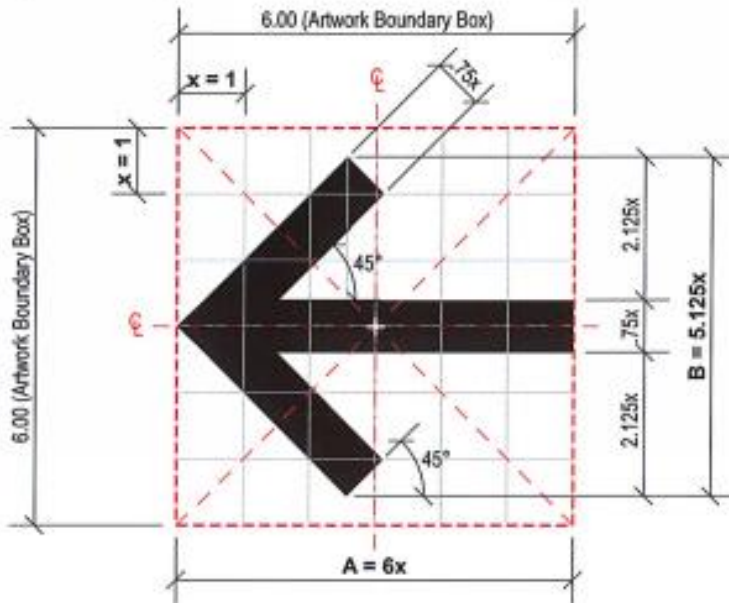


Figure 4.7.10 Universal Symbols: Graphic Element Description

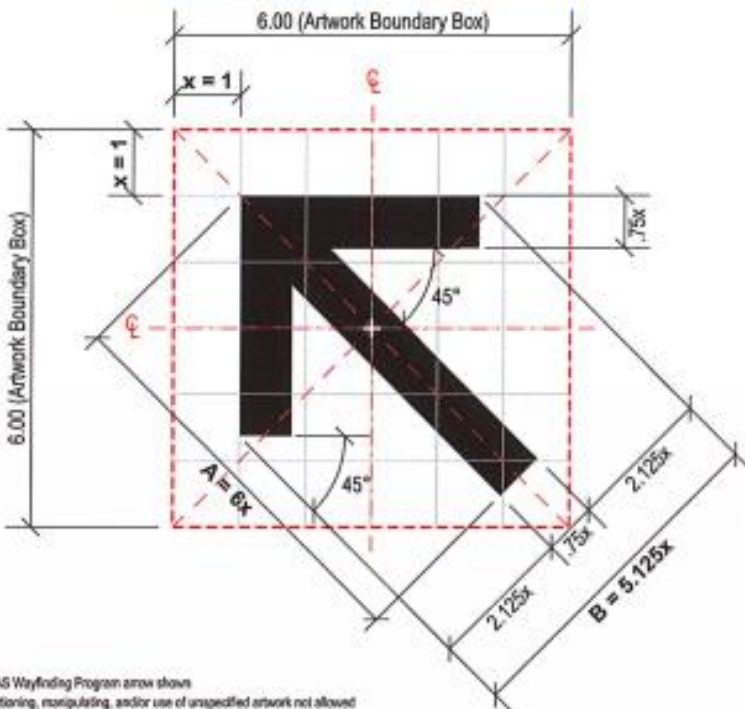
- 4.8.1 ARROWS:** When used as directional elements, are more flexible and require less sign layout space than messages. This section defines the standards for HAS wayfinding arrows and their rotation angles, sizes, proportions, applications and general placement.
- 4.8.2 Arrow Proportions:** The standard HAS directional arrow (as shown in Figure 4.8.2) must always be proportionally consistent (width-to-height ratio) throughout the entire sign system, regardless of the sign type or layout that it is being applied to. It should never be disproportioned, squashed or stretched in any dimension in order to make it fit on a sign face with limited size, or for any other circumstance. Typical proportioning between arrow and message sizes for the HAS wayfinding sign system will be determined as follows:
- Pedestrian wayfinding signage:
 - By individual sign face layout sizes, sign locations, visibility distances/ angles, mounting heights and per ADA requirements.
 - Vehicular wayfinding signage:
 - By individual sign layout sizes, sign locations, visibility distances/angles, mounting heights, posted speeds and per MUTCD/TXDOT standards.
- 4.8.3 Arrow Size Scaling:** When scaling an arrow, it must always be locked at its default proportions as shown in Figure 4.8.2. This will eliminate the possibility of skewing the arrow's proportions when scaling it for use on differently sized sign face layouts.

NOTE: Always refer to actual HAS wayfinding signage face layouts for all final definitive arrow sizing per each individual sign type as shown in current HAS wayfinding signage design intent/construction documents.

Straight Arrow: (Use for arrows angled at: 0°, 90°, 180°, 270°)



Angled Arrow: (Use for arrows angled at: 45°, 135°, 225°, 315°)



NOTES:

- Scale = 1:3
- Standard HAS Wayfinding Program arrow shown
- Re-proportioning, manipulating, and/or use of unspecified artwork not allowed
- Use only approved rotation angles as shown here
- Artwork Boundary Box always to remain same square proportions as shown
- No other artwork elements to infringe or overlap Boundary Box edges
- Always rotate arrow at exact center point of Boundary Box
- Arrow proportion ratio = A:B
- x = 1; A = 6x; B = 5.125x

Figure 4.8.2 HAS Wayfinding Arrow: Artwork & Proportions

4.8.4 Arrow Placement and Text Alignment: The placement of arrows on sign faces and in relation to message text will conform to the standard guidelines provided for each specific sign type and their corresponding traffic type (i.e. Pedestrian or Vehicular), as well as all applicable ADA and MUTCD/TXDOT requirements. Arrows and their related message text may not be positioned in any other location on the sign face unless otherwise indicated. When new and/or customized sign types or layouts are necessary, the following general guidelines and restrictions apply to arrows and their corresponding message text alignment:

- Pedestrian: General Arrow Placement
 - Arrows should NEVER point into text.
 - Left-facing arrows should be located toward the left side of signs
 - Right-facing arrows should be located toward the right side of signs
 - Forward-facing and/or downward-facing arrows are typically located closest to the flow of traffic
- Pedestrian: General Text Alignment with Arrows
 - Left-facing arrows require left justified message text/symbols
 - Right-facing arrows require right justified message text/symbols
 - Forward-facing and/or downward-facing arrows require text/symbols to be justified closest to the flow of traffic (i.e. if forward traffic is hugging the right side of a corridor, the arrow should be on the right side of the face with the text justified right, and vice versa)
- Vehicular: General Arrow Placement
 - Roadside left-facing arrows should be located toward the left side of signs
 - Roadside right-facing arrows should be located toward the right side of signs
 - Forward-facing and/or Downward-facing arrows on overhead signs are typically centered over their corresponding traffic lanes
 - Forward-facing and/or Downward-facing arrows on roadside signs are typically located closest to the flow of traffic or centered (depending on the sign type's use and layout)
- Vehicular: General Text Alignment with Arrows
 - Left-facing arrows require left justified message text/symbols, unless otherwise noted or required by MUTCD/TXDOT
 - Right-facing arrows require right justified message text/symbols, unless otherwise noted or required by MUTCD/TXDOT
 - Forward-facing arrows on roadside signs typically use text justified toward traffic flow, while overhead signs typically use centered text/arrows

4.8.5 Arrow Rotation: A consistent rotation angle and the directional information that an arrow conveys is as important as the accompanying message text. The rotation angle that conveys "straight ahead" is particularly notable. For example, either an "up" arrow (12 o'clock) or a "down" arrow (6 o'clock) can be used to convey forward movement, and is typically interpreted differently based on a sign's given location, relative pathway conditions and/or the type of wayfinding traffic that is viewing it.

Note that arrow rotation angle selection must always be done so consistently throughout the entire HAS wayfinding system and in accordance with these established arrow rotation standards. The following are general guidelines for the selection and use of arrow rotation:

- The standard wayfinding arrow can be rendered in eight (8) different pre-determined rotation angles (refer to Appendix Volume 5 for Pedestrian and Vehicular wayfinding Arrow Applications). No alternate rotation angles are acceptable, unless approved by HAS.
- Arrow rotation angles should follow the guidelines provided in this section. Straight-ahead pedestrian movement will always be indicated at HAS properties by upward-facing arrows (12 o'clock), unless a downward-facing arrow can be shown to be clearly advantageous in a specific circumstance (i.e. "use this lane"). Note that straight downward-facing arrows (6 o'clock) are typically reserved to indicate movement to a lower level (i.e. at the top of a down stairway or escalator).
- Vehicular wayfinding arrow rotation will always follow MUTCD/TXDOT reqs.
- For a full list of acceptable arrow applications, rotation angles and their designated message interpretations for Wayfinding arrows refer to Appendix Volume 5 for Pedestrian and Vehicular wayfinding Arrow Applications

4.9.1 COLOR OVERVIEW: In order to maintain a visually unified system of signs throughout all HAS properties, the presentation of color must be consistent on all elements throughout the entirety of the HAS wayfinding signage system. This section will provide an overview of the adopted color system as it is to be used for all new and updated wayfinding signage at HAS properties.

4.9.2 Color Effects on Human Behavior: Color has been presented within many professional studies as having substantial emotional and perceptual influences on human behavior. Such studies typically provide numerous details and well-researched reasoning regarding the use of color as it pertains to human interaction with complex informational systems, which are too detailed and lengthy for inclusion within this document. However, using similar philosophies, most wayfinding industry experts agree that color has a profound and quantifiable effect on wayfinding within complex environments, and as such typically create color systems to accommodate unique wayfinding conditions as required. The importance of understanding and utilizing such color-related philosophies within any wayfinding system is paramount to implementing signage that is easily understood by most users, without introducing additional layers of information to decipher.

4.9.3 Color Design Considerations: The following general design considerations and guidelines were utilized when specifying and designing the updated HAS wayfinding color system:

- Simple, Supplemental and Consistent:
 - Colors, as they pertain to branding specific elements within a wayfinding environment, should always be simple, supplemental, limited in number and applied consistently and without exception. When too many colors are introduced, it will typically create an additional layer of information to decipher, which in turn may cause increased confusion, pause and distrust of the wayfinding system.
- Consideration of Colorblind Individuals:
 - It should be noted that as of this document's publishing, approximately 12 percent of the population is colorblind and cannot distinguish between mixed shades of red or orange, yellow or brown and black or blue. For this reason, if multiple colors are to be used as a primary means of identifying wayfinding elements (i.e. "The Orange Line," "The Green Room," etc.), then it would be necessary to spell out the name of the color in order to make the intended color usage clear to colorblind individuals, while also meeting related ADA requirements.
- Color-Coding:
 - Color-coding, when applied thoughtfully, sparingly and consistently, is useful supplement to a good linguistic format. Color-coding should not typically be the absolute or primary means of distinguishing parts of a facility, and instead be used in a manner that supplements the primary graphic wayfinding information being presented. For example, applying a unique color to each individual level or area of a parking garage is a common practice among parking facility designers. However, the color use of such a color system must be considered within the larger context of the surrounding/nearby facilities and how it will affect their color-coding

systems. When too many varied colors and/or color systems are used, color becomes yet one more layer to decipher in an already complex hierarchy of wayfinding information.

- Recognition, Contrast, Reproduction and Environmental Considerations:
 - Colors should always be chosen for their wide recognition, contrast/ legibility, ease of manufacture/reproduction, as well as complementary to the established wayfinding system or surrounding environment. The long-term “survivability” of colors will also be dependent on surrounding weather and environmental conditions (i.e. direct sunlight and ambient light gradually affects color systems over time, typically fading and usually accelerated due to unique or typical local weather conditions). As such, the choice and use of color should always be evaluated to some degree based on the geographic location of the wayfinding environment.

4.10.1 COLOR APPLICATION - HAS Wayfinding Color System: The HAS wayfinding system’s color palette has been updated to create an effective new *supplemental* wayfinding specific color-coding system that accents and enhances the messaging, while also limiting the use of other branded and/ or non-wayfinding related colors. In addition, all updated colors were chosen to be consistently and easily manufactured on signage, maintain good contrast with each other, and appear as a distinctive wayfinding-specific color palette that is easily recognized by most wayfinding system users, regardless of location within the airport property.

4.10.2 General Color Guidelines and Standards: The following are general color guidelines and standards for use within the HAS wayfinding signage system (refer to Appendix Volume 5 for additional graphic descriptions, application information and manufacturer’s equivalents):

- Sign Graphics - All HAS Wayfinding Signage:
 - The primary sign face background and text colors for all wayfinding signage (vehicular and pedestrian) are White text/symbols on an HAS Wayfinding Dark Gray (PMS 433C) background. These colors were chosen for their widely adopted implementation system wide at IAH, their high contrast and their neutral affect when incorporated within the multitude of IAH’s varied wayfinding environments (both interior and exterior areas)
- Sign Graphics - Pedestrian Wayfinding Areas (i.e. terminals, curbsides, pedestrian-related parking areas):
 - The use of White text/symbols on a HAS Wayfinding Dark Gray sign face background avoids competition with color schemes of other competing entities (concessions, airlines, etc..) and integrates well with the varying structural and architectural features found at HAS properties
- Sign Graphics - Vehicular Wayfinding Signs (i.e. roadways and vehicular- related parking areas)
 - White text/symbols on a HAS Wayfinding Dark Gray sign face background creates high contrast and greater legibility from a distance, while traveling at posted speeds.
 - This also distinguishes the airport’s wayfinding sign system from surrounding city, county or state road sign systems.
 - It also serves to alert motorists that they are traveling within the airport’s property limits, and more complex movements will occur in shorter distances.
 - As a means of enhancing the visual queue of leaving the airport’s property limits and entering the surrounding city roadway system, roadway directionals nearest to airport exit/property limit areas will utilize TXDOT green backgrounds and graphic formatting.
 - HOU special roadway signage color condition: because the perimeter roadways around the HOU property are part of the surrounding community road system, the HOU roadway signs will utilize a custom dark green color (“Waller Green”) with White text/symbols.
- Branded Terminal Identification (refer to Appendix Volume 5): In order to identify each terminal as a separate facility at IAH, the terminals will be branded with the following color identification system:
 - Terminal A = Green (PMS 349C)
 - Terminal B = Purple (PMS 2597C)
 - Terminal C = Blue (PMS 300C)
 - Terminal D = Red (PMS 187C)
 - Terminal E = Orange (PMS 1655C)

- HOU = use Neutral Silver
- EFD = use Neutral Silver
- Global Watermark Accent Graphics (refer to Appendix Volume 5): Along with the primary terminal identification color, the “Global Watermark” accent graphics will utilize the following colors:
 - IAH Terminal A = Green (PMS 3435C)
 - IAH Terminal B = Purple (PMS 2695C)
 - IAH Terminal C = Blue (PMS 294C)
 - IAH Terminal D = Red (PMS 188C)
 - IAH Terminal E = Orange (PMS 180C)
 - HOU = use Neutral Gray (PMS 430C)
 - EFD = use Neutral Gray (PMS 430C)
- Inter-Terminal Train Systems at IAH (refer to Appendix Volume 5): The Inter-Terminal Train systems (i.e. Skyway = secured area access/ elevated system; Subway = non-secured area access/underground system) at IAH will utilize the following colors:
 - Primary ID Color = Yellow (PMS 3965C)
 - Global Watermark Accent = Dark Yellow (PMS 3975C)

Note Message text spelled out as “Skyway” or “Subway” on all wayfinding signage (i.e. directional, identification and informational) will always be Yellow (PMS 3965C) to purposefully differentiate and visually stand out as unique messaging

- Parking Garage Identification (refer to Appendix Volume 5):
 - IAH = All parking garages are branded with and use the same branded color ID as the corresponding attached Terminal(s) on all garage levels:
 - Parking A = Green (PMS 349C)
 - Parking B = Purple (PMS 2597C)
 - Parking C = Blue (PMS 300C)
 - Parking D = Red (PMS 187C)
 - Parking E = Orange (PMS 1655C)
 - HOU Red Garage (aka “Existing Garage” = Red (PMS 187C)
 - HOU Blue Garage (aka “New Garage” = Blue (PMS 300C)
 - Ecopark Lot = Green (PMS 349C); Note; only applied at HOU
 - EFD = N/A

4.10.3 OTHER COLOR CONSIDERATIONS

- Consistent and Holistic Application: To remain effective, the HAS wayfinding color system must always be applied to all wayfinding system elements in a consistent and holistic manner airport-wide (roadways, parking, curbsides, ground transportation areas, terminals, etc.) and at all HAS properties.
- Supplemental Colors:
 - The addition of any/all supplemental colors must always be carefully considered during design of new airport areas and their respective signage design programs in order to determine how they will mesh with the overall established HAS color-coding and wayfinding systems.
 - All supplemental colors must be coordinated with and approved by HAS.
 - All supplemental colors must always maintain all legibility and compatibility criteria as mentioned in this section, as well as any applicable ADA/Texas ADA and MUTCD/TXDOT requirements regarding color-use on signage.
- Additional Use of Color
 - Certain signs within the airport complex may employ the corporate colors of airlines, rental car agencies, concessionaires and other airport tenants as dictated and/or deemed appropriate by HAS.
 - No other colors are to be used for HAS wayfinding signage or sign hardware used within HAS properties unless otherwise approved by HAS.

4.11.1 ART, ADVERTISING AND AMENITIES

NOTE: Design standards for art, advertising and amenity signage is not covered within this document; see the most recent editions of HAS art, advertising and amenity design standard documentation for all applicable requirements

Airports typically have several elements and systems that compete with pedestrian wayfinding signage. These include (but may not be limited to) art, advertising and amenity related signage. Consistent and sensible location of wayfinding signage in relation to each of these elements will ensure an effective and positive wayfinding experience. This section provides general guidelines and recommendations for effective placement of wayfinding signage in relation to these other nearby elements.

4.11.2 General Placement Guidelines: HAS' "Wayfinding Signage Philosophies" place a priority on ease of wayfinding throughout all of its properties. As a result, the HAS wayfinding system will typically take visibility and placement priority over other nearby systems such as art, advertising and amenity elements. However, it must also maintain general harmony with regards to visibility and general placement in relation to these other nearby systems. The following general guidelines have been established and are to be used by all designers specifying wayfinding signage within HAS airport properties

Placement of wayfinding signage in relation to art, advertising and amenity elements shall always be done so in a manner that maximizes the visibility of each without obstructing important wayfinding information. As such, a simple grid system should be used by designers to maximize the placement of each element. This grid system is based on a simple X/Y/Z axis system (i.e. X= horizontal axis; Y= vertical axis; Z = third-dimension axis, or "forward/ backward" in relation to the viewer's position).

The following are general guidelines to be used as a reference for placing wayfinding signage in relation to art, advertising and amenity elements (see Figure 4.11.2):

- Typical Vertical Placement:
 - Vertical placement of wayfinding signage and nearby elements will use an established set of three-dimensional spatial zones along the Y-axis plane and extend forward/backward along the Z-axis plane.
- Typical Horizontal Placement:
 - Horizontal placement of wayfinding signage and nearby elements will use an established set of three-dimensional spatial zones along the X-axis plane and extend forward/backward along the Z-axis plane.

4.11.3 Signage Zones: Basic placement zones have been provided here for locating HAS wayfinding signage in relation to art, advertising and amenity related elements (see Figure 4.11.2). The following general guidelines should be utilized when locating wayfinding signage near these elements (Note: A.F.F. = "above finished floor"):

- Overhead Wayfinding Zone: is a +/- 3'-0" high three-dimensional spatial plane dedicated to placement of overhead pedestrian wayfinding signage
 - Typical vertical zone size = +/- 8'-6" A.F.F. to 11'-6" A.F.F.
 - Note that the zone may also extend above or below these dimensions if deemed appropriate for a given location's conditions and requirements.
 - The line-of-sight for this zone should always maintain an unobstructed view of 50'-0" minimum on the Z-axis plane approach.
- Amenity Zone: is a +/- 2'-6" high three-dimensional spatial plane that applies to placement of signage and/or elements for amenities (i.e. restaurants, taverns, retail shops, concessions, etc.).
 - Typical vertical zone size = +/- 6'-8" A.F.F. to 8'-6" A.F.F.
 - Placement of amenity elements within this zone are dependent upon established HAS amenity signage design standards and per individual terminal facility conditions; wayfinding signage should typically maintain a +/- 10'-0" min. horizontal perimeter away from amenity signage/ elements whenever possible.
- Lower Wayfinding/Art & Advertising Zone: is a +/- 6'-8" high three-dimensional spatial plane that applies to placement of lower wayfinding signage (i.e. floor mounted and lower wall mounted sign

types), as well as concessions, art and advertising elements typically scaled for more personal interaction/viewing.

- Typical vertical zone size = Finished Floor to +/- 6'-8" A.F.F.
- Art, advertising and freestanding concession elements in this area should typically maintain a horizontal perimeter of +/- 10'-0" min. from wayfinding elements whenever possible.
- Overhead Art & Advertising Zone: Note that overhead art & advertising requires flexibility in sizing and spacing and is preferred to occur above the Overhead Wayfinding Zone whenever possible (typically above 11'-6" A.F.F. or as deemed appropriate for a given location's conditions or sizing requirements and is dependent on individual terminal facility conditions).

NOTE: Dimensions shown here are to be used as a general guideline only; some overlap of zones is to be expected and may occur depending on unique terminal environment conditions and sizing of wayfinding signage and existing/ planned art, advertising and amenity elements; designers are required to review all wayfinding signage in relation to art, advertising and amenity elements as location conditions require, and adjust placements as necessary.

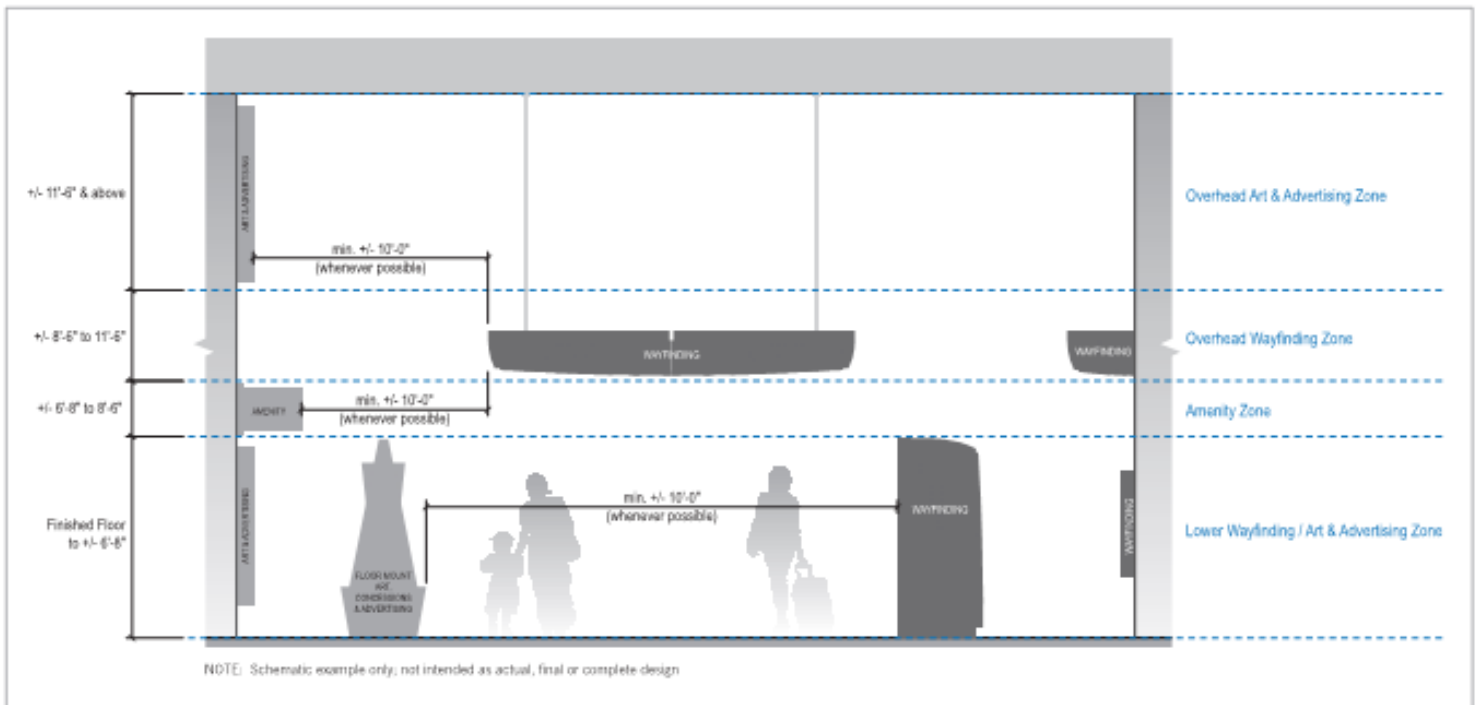


Figure 4.11.2 Typical Signage Zones

NOTE: These documents are intended to illustrate design intent and should only be used as a general guideline. No information contained here should be construed as engineered elements. The fabricator/contractor/installer shall be responsible for all engineering and specifications in regard to structural, electrical, mechanical, foundation and installation.



HAS WAYFINDING SYSTEM

Signage Design Guidelines, Standards and Typical Applications

VOLUME 2.0

- 2.1 Wayfinding Application
- 2.2 Wayfinding Sign System Overview
- 2.3 Wayfinding Sign Families - IAH

TYPICAL WAYFINDING ANALYSIS AND APPLICATION

Prior to developing updated wayfinding signage design standards, it was fundamental to understand the existing wayfinding signage at HAS airport properties. In order to establish a clear direction in which to move forward with the updated wayfinding signage program, LAI analyzed all relevant existing materials by site visits, capturing photographic examples, and reviewing existing and/or planned sign program documentation at each property.

Evaluation Criteria

It is important for wayfinding signs to adhere to a basic guideline of copy styles/sizes, maintain consistent terminology, use recognizable and universally accepted symbols, incorporate uniform colors systems, and utilize consistent recognizable sign types. This section covers key elements that impact the effectiveness of a wayfinding signage system, as well as overall wayfinding processes at airports in general. LAI used these key elements as the criteria by which the existing signage system was evaluated, and will continue to use for implementing new wayfinding signage within HAS modernization programs. Note that industry standard wayfinding and signage factors are covered in additional detail within the following documents:

- Guidelines for Airport Signing and Graphics - Terminal and Landside, Third Edition 2001
- ACRP Report 52 - Wayfinding and Signing Guidelines for Airport Terminals and Landside – 2011
- Americans with Disabilities Act – 2010 ADA Standards for Accessible Design – Latest Revisions

The following are general descriptions of the evaluation criteria used for analyzing the HAS wayfinding program:

- **Signage Philosophy:** Establish an integrated framework that would produce ONE comprehensive, holistic and visually attractive signage system that can be easily understood, followed and identified.
- **Standard Terminology:** Experience the same terms and sign types from one terminal, facility or area to the next, which will assist in rapid public comprehension of various airport functions/destinations. Message content must be in layman's language, equally understandable by first-time and frequent travelers.
- **Message Hierarchy:** Clear and concise information presented by “primary,” “secondary” and “tertiary” sets of messages greatly improves efficient passenger flow.
- **Color Coding:** Colors have great effect on human behavior and deciphering wayfinding information. Thoughtful consideration and consistent implementation should always be utilized when using multiple colors within a wayfinding sign system.
- **Symbols:** The use of short verbal messages in conjunction with symbols is more effective than the use of messages or symbols alone. The use of consistent graphic representations and sizing of symbols and arrows maintains system cohesion and more rapid information deciphering.

Limiting the number of arrows at a given decision point also greatly improves information deciphering and passenger flow.

- **Scale of Copy:** In a fast paced, often congested environment such as an airport, a conservative pedestrian viewing distance of 25 feet of viewing distance to each inch of capital letter height should be used.
- **Sign Placement:** Placement of signs at key decision points and/or in the direct line of sight of the traveling public reduces decision times. A reasonable range of 75 to 125 feet between major directional overhead signs is acceptable and meets the general intent of ADA guidelines. Using signs at regular intervals within longer contained corridors reinforces wayfinding information and improves traffic flow.

Conceptual Wayfinding Plans

Conceptual Wayfinding Plans identify conceptual wayfinding pathways, decision points and sign locations for wayfinding signage to be implemented within all HAS modernization programs. They will be used only as a general starting point/guideline for initial conceptual sign location reference within each applicable improvement program. More finalized and exact locations will be implemented during design development processes, and coordinated with HAS.

Interim (Temporary) Wayfinding

In addition to the established new HAS wayfinding signage system, a transitional sign system should also be developed and employed during interim wayfinding conditions. A conceptual transitional wayfinding sign family should be considered and developed by designers during design phases as needed.

The following are initial recommendations for an effective transitional wayfinding signage system:

- A stand-alone or supplemental graphic/wayfinding “roll-out” campaign
- Emphasis on highly visible transitional signage that matches the general design/graphic intent of the final permanent signage
- Fabrication, installation and revision time = very fast/expedited
- Easy on-site and “on-the-fly” revisions and sign adjustments
- Will educate users with the new wayfinding program’s graphics, shapes, terminology, etc.
- Will allow time to properly study, evaluate & address the most effective permanent wayfinding signage locations and solutions, while not compromising passenger circulation efficiency
- Fabrication considerations:
 - Constructed of low-cost materials to last the duration of the transitional period
 - Light-weight inexpensive sign face/background materials
 - Gatorfoam, Sintra, MDO plywood, etc.
 - Graphics = 1st surface applied digitally cut vinyl, or full-bleed graphics printed on surface applied vinyl
 - Temporary printed sign face cover-wraps to cover permanent signage with transitional messaging/graphics
 - Banner materials

- Over-the-face (aka “wrap”) configurations
- Temporary surface applied vinyl “super-graphics”
 - Draw additional attention to important vertical and/or horizontal travel areas and destinations; to be seen from greater distances for earlier queuing
- Freestanding moveable sign base systems
 - Gatorfoam with aluminum clamp bases
 - Pre-fabricated (off-the-shelf) units with slide-in graphic panel areas
- Implementation phasing based on HAS modernization program scheduling (TBD by others and coordinated with HAS)

Final Wayfinding Plans and Signage Design Intent

The wayfinding plans shown in this document are conceptual only and are based on the most recent architectural files as provided to LAI by the Project Team at time of this document's publication. The sign family shown in this document is also considered in development and may require further refinement and/or additional sign types as deemed necessary during future design development processes. Final wayfinding plans, sign location plans and signage design intent drawings will all be further developed and refined during the course of HAS' modernization programs.

Case Studies – IAH Existing Conditions

Used as a baseline for all HAS airport properties, the existing wayfinding signage conditions found within the IAH property and its associated facilities were surveyed and documented by LAI with the assistance of CH2MHill, Bradlink, LLC and HAS' in-house Sign Shop. Photos were taken of existing sign locations found within IAH's main public accessible areas across multiple facilities. Typical wayfinding pathways at IAH were captured with photos, and included departing, arriving and connecting routes, which in turn were used to generate computer-generated photo rendering “walk-thru” analysis, and presented to HAS using interactive Powerpoint presentations.

See the following sections in this document for detailed examples of additional case studies and their related materials:

Chapter 5.0: Appendix: *(NOTE: this section not included in this document; available upon request)*

- Section 5.1 Wayfinding Photos: Case Studies - IAH
- Subsection 5.1.1. Terminal C Example:
- Section 5.2: Wayfinding Application: Case Studies - IAH, 5.2.1 Terminal C Example:
 - 5.2.2.1 Conceptual Wayfinding Plan
 - 5.2.2.2 Conceptual Walk-Thru Simulation
- Section 5.3: Additional Wayfinding Case Studies - HOU
- Section 5.4: Additional Design Process Reference Documentation

WARNING:

This record contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons with a “need to know,” as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies, public disclosure is governed by 5 U.S.C. 552 and 49 CFR parts 15 and 1520.

WAYFINDING FACTORS AND PLANNING

The ability to orient and navigate one’s way through the varying environments as found within HAS airport properties is of fundamental importance. Wayfinding planning using graphic diagrams establishes the analysis of spatial relationships and traffic circulation. All designers are required to utilize similar planning processes as shown here when designing signage for use at HAS properties.

Wayfinding Planning: Circulation Analysis

During design development, incoming and outgoing circulation for major user groups (i.e. pedestrians, vehicular, etc.) shall be analyzed and documented by the designer. Points of origin and destination will be referenced as the basis for identifying critical decision points and message/information/signage requirements.

Primary user circulation routes are depicted as solid-lines with end arrows, pointing in the direction of the individual traffic flow. Dotted lines with end-arrows depict possible alternate circulation routes occurring at direction changes (see Figure 2.1.1).

Wayfinding Planning: Identification of Decision Points

Decision points along user circulation routes are to be located at required direction changes, and points where the user encounters alternative choices. Decision point locations should be shown as larger yellow dotted-line circles at primary traffic-change intersections; in addition, areas where reinforcement is needed (i.e. longer corridors without a change in traffic direction) should be indicated by smaller yellow dotted-line circles (see Figure 2.1.1). These areas are the most optimal location for placing directional signs that inform the user of the nearest existing and alternative wayfinding pathways for consideration.

Determining Required Information at Decision Points

Upon review of an area’s wayfinding conditions, the required messaging/information and signage needed for a given decision point should be determined by the designer using logical thinking and the established standards in this document. The selection of messages identifying wayfinding destinations, as well as the selection of proper sign types should be determined by using the established HAS wayfinding message hierarchy, arrows, universal symbols and wayfinding sign types as listed in this document. In the event that custom wayfinding messaging or signage conditions occur, the designer will document and coordinate the recommended solutions with HAS for review and approval.

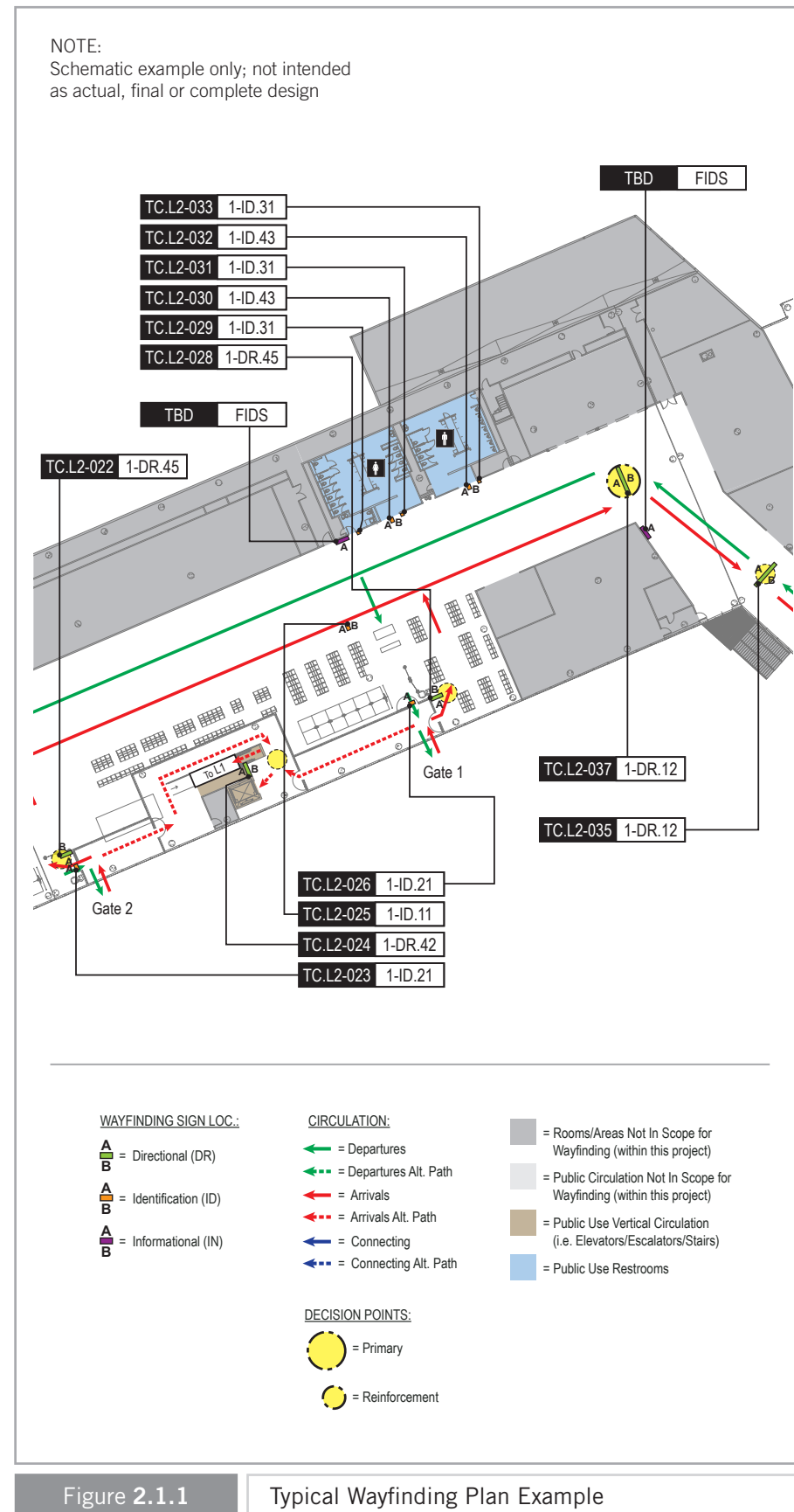


Figure 2.1.1 Typical Wayfinding Plan Example

Identification of Sign Locations

Plans, cross sections and elevation views of related project facility/site spaces shall be analyzed by the designer to make determinations of sign locations. Following review of the architectural/environmental/site conditions, scaled plans will be generated with sign location “bars” (i.e. plan/top view representational boxes indicating the sign’s basic size/shape that are scaled to match the floor plan, and are oriented/rotated as the sign would be in “real world” conditions). Differing and/or multiple sides of each sign should be indicated with a unique alpha designation (such as A, B, etc.) per sign location, and must coincide precisely with the specific sign type and related sign message schedule. Note that all signs will be given a unique sign location annotation box, and will always be accompanied with a leader line extending from each annotation box to its associated sign location bar.

Also note that all overhead sign locations must be coordinated with architectural reflected ceiling plans (aka “RCP’s”) to ensure that no interferences occur with established and/or new architectural/environmental elements. Sign locations will be located in sensible areas nearest to its associated decision point, and in conjunction with existing or planned facility/site structural support elements whenever possible.

Sign Location Annotation

The HAS sign location annotation system established in this document is to be used to identify sign locations on all HAS wayfinding signage related documentation. Within terminal facility related areas (i.e. terminals, concourses, CBP areas, curbside/ground transportation areas and parking garages), each sign shall be given a designation of location as shown on the following page in Figure 2.1.2a. Within airport property roadway areas (i.e. roads within the “Terminal Loop” zone near terminal facilities and perimeter roadways circulating around the airport’s property), each sign shall be given a designation of location as shown on the following page in Figure 2.1.2b.

Message Schedules

All HAS wayfinding signage related projects will include a message schedule, preferably in a graphic format showing examples of actual scaled sign face artwork. Message schedules will always coincide with, and precisely match, their corresponding sign location plan(s), and will account for every sign that is a part of the associated signage project. It will always include (at a minimum) the following elements/information:

- Unique Sign Location Number (i.e. “TA.L2-001,” etc.)
- Sign Type Identification Number (i.e. “1.ID-35,” etc.)
- General description of the sign type (i.e. “Wall Mount Overhead Restroom Entry ID,” etc.)
- Side listings (i.e. “Side A,” “Side B,” etc.)
- Messages shown per side (i.e. graphic depiction of the actual sign face artwork, per each individual sign face side)
- Remarks/Notes (if needed for description of special circumstances, etc.)

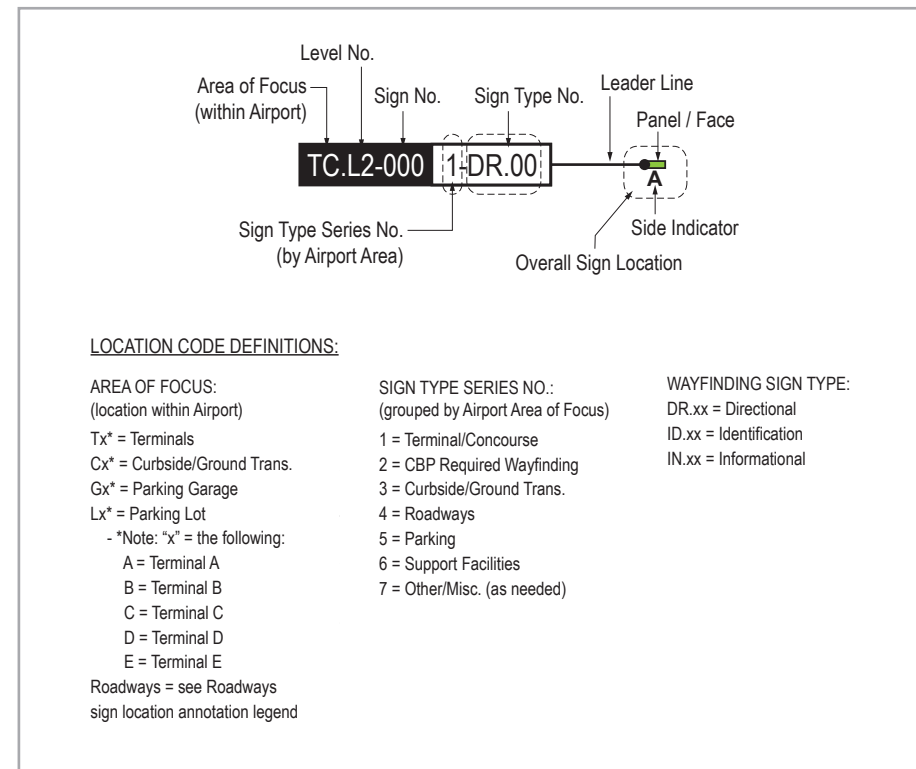


Figure 2.1.2a

Sign Location Annotation - Terminal Facility Areas

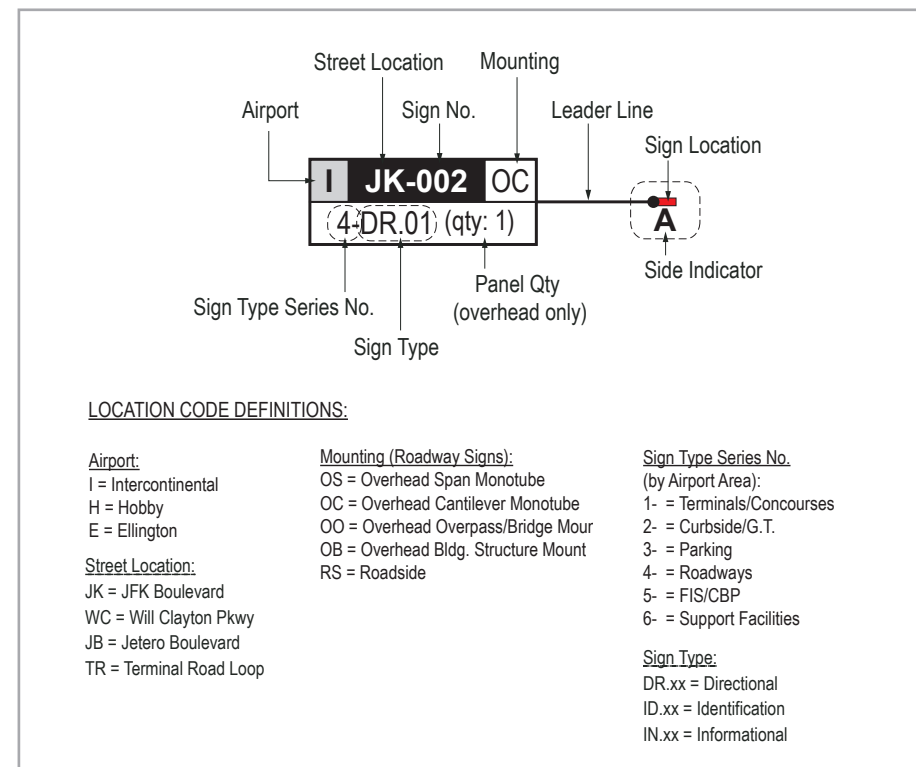


Figure 2.1.2b

Sign Location Annotation - Roadway Areas

GENERAL SIGN PLACEMENT

Viewer circulation patterns and natural lines of vision are the basis for determining the location of all wayfinding signs. Signs shall be located to precede decision points whenever possible. This will ensure sufficient time for users to react to each sign's set of messaging/information.

Sign Placement Considerations - Pedestrian Signage

A general rule for placing wayfinding signage is that a designer visualize themselves as an average departing or arriving passenger within a given airport environment, while thinking logically about decision points and the required messaging expected at a specific location. This guideline is very general in context, however, the requirements of the given sign location will be very specific regarding messaging, sign type and usage.

Note that disorienting conditions may occur, which in turn may require placement of additional or supplemental signage. These typically include:

- Complex architecture/interior environments
- Competing pedestrian wayfinding traffic
- Visual environmental distractions
- Congested architectural spaces/corridors

Favorable conditions which typically reduce need for repetitive signage are:

- Efficient architecture/interior environments
- Single direction wayfinding traffic flow
- Wall or floor treatments reinforcing single-direction traffic flow
- Lighting treatments emphasizing architectural passageways

Sign Placement by Sign Type - Pedestrian Signage

- Directional signs - placement will be perpendicular to wayfinding traffic, and will occur at all decision points and areas where people become disoriented by architectural or environmental conditions. Directional signs will also be placed at reassuring intervals within a captive corridor to reinforce directional messaging to wayfinding traffic. Note that architectural/interior conditions or competing pedestrian traffic flow may also inadvertently imply a change of direction. In these situations, additional directional signs will be used to reinforce the intended direction as needed.
- Identification signs - placement will typically occur at or near all priority destinations and entrances. Identification signs, such as gate ID signs or corridor/building entrances, will also typically be placed perpendicular to wayfinding traffic.
- Informational signs - placement will typically be located nearest major decision points. Directories will typically be located to the side of a major decision point and will be parallel/in-line with wayfinding traffic. FIDS and other dynamic informational systems should also be typically located parallel/in-line with wayfinding traffic unless otherwise deemed beneficial to be perpendicular in a given situation.

Typical Pedestrian Sign Placement Intervals - Best Practices

Placement of signs at key decision points and/or in the direct line of sight of the traveling public reduces decision times. A reasonable range of 75 to 125 feet between major directional overhead signs is typical and meets the general intent of ADA guidelines. Using signs at regular intervals in longer captive corridors reinforces wayfinding information and improves traffic flow.

Sign Placement Considerations - Vehicular Signage

Note that disorienting conditions may occur due to the complex nature of airport roadway systems, which in turn may require placement of additional or supplemental signage. These typically include:

- Complex roadway/roadside/site or construction related conditions
- Competing vehicular wayfinding traffic
- Visual environmental distractions
- Congested traffic conditions

Favorable conditions which typically reduce need for repetitive signage are:

- Efficient/simplified roadway/roadside/site conditions
- Efficient sight lines for drivers of varying driving abilities
- Gradual road curves and exit lanes with adequate length
- Signs located with adequate distance and sizing to queue traffic safely and efficiently at posted speed limits

Sign Placement by Sign Type - Vehicular Signage

- Directional signs - placement will be perpendicular to wayfinding traffic, and will occur at all decision points and areas where drivers become disoriented by roadway or environmental site conditions. Directional signs will also be placed at reassuring intervals to reinforce directional messaging to wayfinding traffic. Note that roadway configurations/conditions or competing vehicular traffic flow may also inadvertently imply a change of direction. In these situations, additional directional signs should be used to reinforce the intended direction as needed per MUTCD/TXDOT requirements.
- Identification signs - placement will typically occur at or near all priority destinations and roadway entrances. Identification signs (such as Airline ID signs), will also typically be placed perpendicular to wayfinding traffic.
- Informational signs - placement will typically be located nearest major decision points. Informational signs will be perpendicular to wayfinding traffic, and will typically be located prior to major decision points and/or near entrances to the corresponding area.

Typical Vehicular Sign Placement Intervals - Best Practices

- Placement of signs at/near key decision points and/or in the direct line of sight of the drivers reduces decision times.
- For vehicular traffic, signs should generally be placed at intervals as deemed appropriate for the given condition. The specific distance used will typically depend on the legibility of the vertical height of the lettering at the posted speed limit (see Section 1.3, Figure 1.3.6 for additional information). NOTE: all MUTCD/TXDOT requirements must always be followed.

SIGN SYSTEM DESCRIPTION

The wayfinding sign system shown in this document is a holistic system being implemented throughout all HAS airport properties. The HAS wayfinding sign system shall always be consistent in appearance and application throughout the entire airport property in which it is being applied. It will also establish a public perception that HAS is a professional and forward-thinking organization, which will always be apparent within any of its airport properties, amenities or facilities.

Design Description – New HAS Wayfinding Signage System

The new HAS wayfinding signage system has been developed to make all airport wayfinding signage an extension of HAS’ world-class branding and philosophies. It was developed to be universally adopted at all three HAS owned Houston Metropolitan Area airports (IAH, HOU, EFD), as well as to meet the established principles of the “HAS Mission and Vision for Wayfinding”:

- Provides safe, efficient and appealing wayfinding at all HAS Airport facilities (IAH, HOU and EFD)
- Reinforces HAS as the “Airport Standard of Excellence in the Americas”
- Unifies signage as one holistic wayfinding system, both interior and exterior
- Shares a consistent, positive “tone-of-voice” at all HAS Airports
- Creates a consistent and shared “sense of arrival” and a “sense of place” at each Airport facility and property

These same principles will always be used for all wayfinding signage implemented within any of HAS’ modernization programs. To see a graphic design description of the HAS wayfinding signage system and examples of the general concept applied, see Section 1.2: HAS Wayfinding System - Design Description.

Sign System Objective: Pedestrian Signage

The general objective of the Pedestrian related wayfinding sign system is to direct the flow of pedestrian traveler traffic at curbside/ground transportation areas, in and out of the public terminal entrances, between appropriate designated terminal areas, in/out of the concourse/gate holdroom or CBP passenger processing areas, and within pedestrian related areas of parking garage facilities. This is achieved by using a hierarchy of signage that relates specifically to pedestrian traffic, and is designed with appropriately sized graphics, visual queuing elements, orientation and placement for such traffic.

Sign System Objective: Vehicular Signage

The general objective of the Vehicular wayfinding sign system is to direct the flow of vehicular traffic in and out of each HAS airport property, as well as throughout their various public-use facilities (i.e. to/from parking facilities, terminal curbs, service areas, etc.). This is achieved by using a hierarchy of signage that relates specifically to vehicular traffic, and is designed with appropriately sized graphics, visual elements/features, orientation and placement for such traffic.

Special Areas

Some areas of the HAS airport properties do not necessarily fall within a specific category, and as such are identified as special areas. A special area will be specifically designed for and reviewed/approved by Airport Management on a

case by case basis as needs require. Examples of special areas may include (but are not limited to) public art, advertising and concession related signage.

Temporary Signage

Sign types developed for temporary/interim conditions shall also use the standards and guidelines for permanent wayfinding signage as shown in this document as a baseline for matching the rest of the wayfinding system.

Exceptions

To be successful, a signage program must allow for flexibility. Exceptions to any of the signage standards and guidelines listed within this document will be reviewed on a case-by-case basis, and enforced by HAS and Airport Management as deemed necessary and appropriate.

SIGN TYPES – GENERAL OVERVIEW

There are several elements that make up a clear and recognizable sign. Even though the message and its copy size/clarity are of great importance, so too is the actual sign entity that it is placed on. Having consistent and distinct sign types enhances a sign system by being more recognizable to its users within unfamiliar environments. Many travelers can decipher the type of information that will be given based on the size, shape, mounting location or color of the sign. This shortens the decision-making process, creating smoother traffic flow and increased trust in the overall wayfinding system.

Sign types will typically be used based on their message priority and basic function:

- Primary Signs Types: Signs used for priority destinations/functions of the airport are considered “Primary” signage, and should be the most visible and visually dominate to other wayfinding signage.
- Secondary Sign Types: Secondary messaging (such as Telephones, ATM, etc.) should typically be reserved for sign types pre-determined as “Secondary” in nature, and should appear visually subordinate to the Primary signage.
- Tertiary Sign Types: Tertiary messaging (such as regulatory, safety related information, etc.) should also be placed on sign types pre-determined for “Tertiary” use, and should appear visually subordinate to both Primary and Secondary signage.

Wayfinding Sign Family

HAS’ new wayfinding system uses a comprehensive sign typing system that is based on categories of a sign’s function. It has been developed into a holistic family of signs with each member having their own specific use and purpose, while also utilizing a “kit-of-parts” design philosophy. It is designed to be manageable, seamlessly integrated within all of HAS’ facilities, and can be updated on a continuing basis as needs arise.

Wayfinding sign types at HAS properties will be categorized as directional, identification, informational, regulatory, life-safety/egress and temporary. Major sign type classifications (as categorized by function) and general descriptions of each include:

- Directional: signs that display standardized directional messaging to assist in finding one’s way through a defined area or environment (i.e. an overhead sign at a decision point with arrow/symbol/destination messages listed).
- Identification: signs used as unique markers to identify specific locations within a defined area or environment (i.e. a gate identification sign).
- Informational: signs or graphic systems that display specific and very detailed information to assist in orientation within a complex or unfamiliar environment (i.e. a directory map or FIDS).
- Regulatory: signs that display regulatory information (i.e. “No Parking” or “Loading Zone Only” signs).
 - Note: not included as part of this document.
- Life-Safety/Egress: signs that display life-safety and vertical circulation/egress related information as required by local and national codes (i.e. fire escape stairway core level identification signs).
 - Note: not included as part of this document.
- Temporary (aka “Interim”): signs that can be directional, identification, informational and regulatory, but are made of temporary materials and mounting methods.
 - Note: not included as part of this document.

The following wayfinding sign families are included within this document (see Sections 2.3, 3.1 and 4.1):

- Terminals/Concourses - IAH see 2.3.1; HOU see 3.1.1
- Supplemental Spanish Signs (HOU only) - see 3.1.2
- U.S. Customs and Border Protection (CBP) - see 2.3.2
- Curbside/Ground Transportation - IAH see 2.3.3; HOU see 3.1.3
- Roadways - IAH see 2.3.4; HOU see 3.1.4; EFD see 4.1.1
- Parking - IAH see 2.3.5; HOU see 3.1.5

Note: All sign types shown in this document are intended as design intent only; Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions/etc.; additional sign types not shown in this document may be required as determined during design processes of individual HAS improvement programs.

Scale and Sizing

Scale and sizing for all HAS wayfinding signage will be consistent and designed to the appropriate required viewing distances for a given condition or environment, as well as to the minimum ADA and/or MUTCD/TXDOT requirements. *Note that the sign types shown in Sections 2.3, 3.1 and 4.1 are for typical conditions only and are designed to accommodate minimum ADA and MUTCD/TXDOT requirements (i.e. minimum 3” capital height letters on pedestrian overhead signs at approximately +/- 8’-0” above finished floor to bottom of sign). Adjustments to the scale and size of certain sign types may be necessary to maximize visibility and aesthetic harmony within a given wayfinding condition or environment during design development. As such, all designers specifying wayfinding signage for use at HAS properties will review all individual spatial and environmental conditions per each modernization program, and make recommendations for scale/size adjustment as deemed appropriate.*

SIGN TYPE IDENTIFICATION SYSTEM

The vast amount of differing architectural and site conditions at HAS properties, combined with the need to meet requirements for pedestrian and vehicular wayfinding visibility, creates a need for a comprehensive and holistic sign identification system. This system will always maintain standardization, flexibility and ease-of-understanding for the majority of individuals specifying and programming updated and new wayfinding signage at HAS properties. All HAS wayfinding signage is to be grouped into the following categories:

- Pedestrian Signs (*NOTE: Certain vehicular signs also fall within these Series numbers)
 - Series 1: Terminals / Concourses: Includes: All public-accessible Terminal and Concourse related areas
 - Series 2: CBP Required Signage: Includes: Areas as controlled by the U.S. Customs and Border Protection
 - *Series 3: Curbside / Ground Transportation: Includes: All Curbside and Ground Transportation related areas
 - *Series 5: Parking: Includes: All on-property public-accessible garages and surface lots
- Vehicular Signs
 - Series 4: Roadways: Includes: All on-property public-accessible roads
- Other Areas
 - Series 6: Support Facility Areas
 - Series 7 (and above): Are to be assigned as needed and based on unique requirements of individual projects. Note that all expanded series numbering and categorization must be coordinated with HAS for final approval.

Pedestrian vs. Vehicular Sign Identification Systems

Pedestrian and vehicular wayfinding signage will always use similar sign type numbering and categorization methods to maintain a holistic identification system across the entire wayfinding program (see Figure 2.2.1). However, each traffic type also have unique requirements and/or mounting configurations associated with them. As such, the sign identification system is more effective when supplemental designators are applied to their respective systems as needed.

Roadway Signage - Unique Mounting Designator

See Figure 2.2.1, "Roadway Signage Mounting Designator" detail for a general description of the unique designator that is to be applied to all HAS roadway wayfinding signage, as well as how to use it for roadway signage identification (see also Figure 2.1.2b for additional information regarding roadway signage location annotation standards).

Variant/Option Designator

When a sign type requires a variant or option (due to sizing variations, directional end-facing, etc.), a unique designator using a lowercase letter at the end of the sign number shall be used. For example, a wall mount directional sign type "1-DR.23" is designed for a left-pointing only directional layout. However, when a right-pointing layout is required, the curved edge must appear on the right side. In this instance, "1-DR.23b" would be used to designate the right-facing variant.

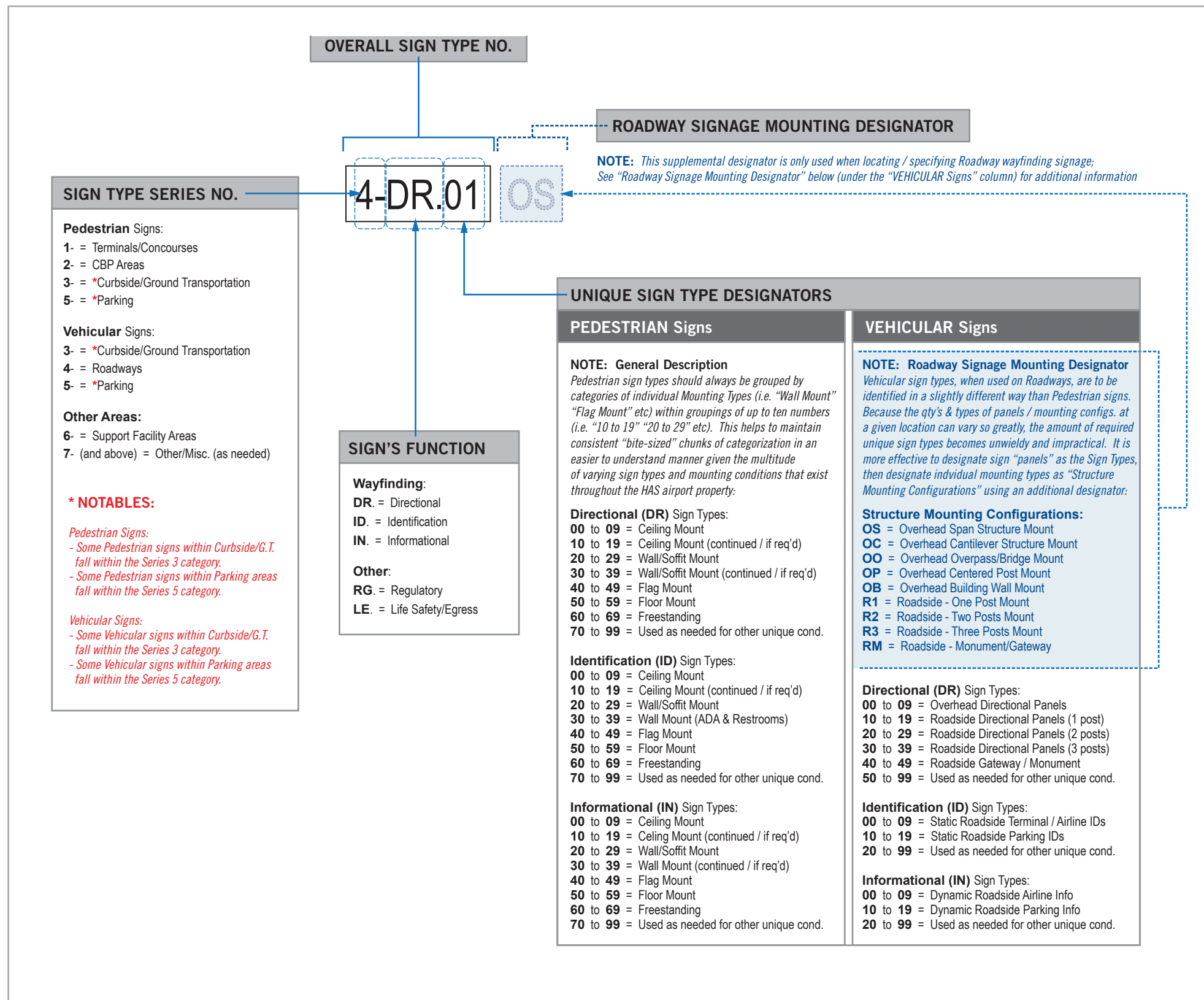


Figure 2.2.1 HAS Wayfinding Sign Type Identification System

KIT-OF-PARTS SIGNAGE SYSTEM

The HAS wayfinding system has been designed as a series of modular sign types that utilize a general “kit-of-parts” system. In most instances, the same and/or similar parts can be used to create multiple differing sign types and mounting configurations.

For example, a Sign Type “1-DR.13” (aka “Ceiling Mount Directional - Suspended, 2-sided with 1 direction and 1-2 messages”) is assembled by using a specific set of parts, which includes two Sign Face Units (sides A and B), a Support / Raceway Unit (i.e. for primary structural support and/or routing internal

electrical components if needed), a Global Element Unit (i.e. for Terminal ID color branding accent) and a Suspension Support Tube System (i.e. used if sign is to be located in high-ceiling areas). See Assembly Example 1 in Figure 2.2.2a.

Another example is the assembly of a Sign Type “1-DR.12” (aka “Ceiling Mount Directional - Suspended, 2-sided with 2 directions and 1-2 messages”). This sign type can be assembled by using two sets of the same parts that make a Sign Type “1-DR.13.” These two “1-DR.13’s” can then be fastened together on the two flat ends of the Global Element Units with an internal connection system (see Assembly Example 2 in Figure 2.2.2b).

Other mounting configurations and part sizes/shapes can be utilized in a similar manner across the entirety of the HAS wayfinding system. For example, a Sign Type “1-DR.23” (aka “Wall / Soffit Mount Directional, 1-sided with 1 direction and 1-2 messages”) can be made by using the same Sign Face Unit as used on the “1-DR.13.” However, it would instead use a Support / Raceway Unit and Global Element Unit that are configured specifically for wall mounting conditions.

NOTE: See Section 2.3 Wayfinding Sign Families - IAH in this document for examples of typical HAS wayfinding sign types.

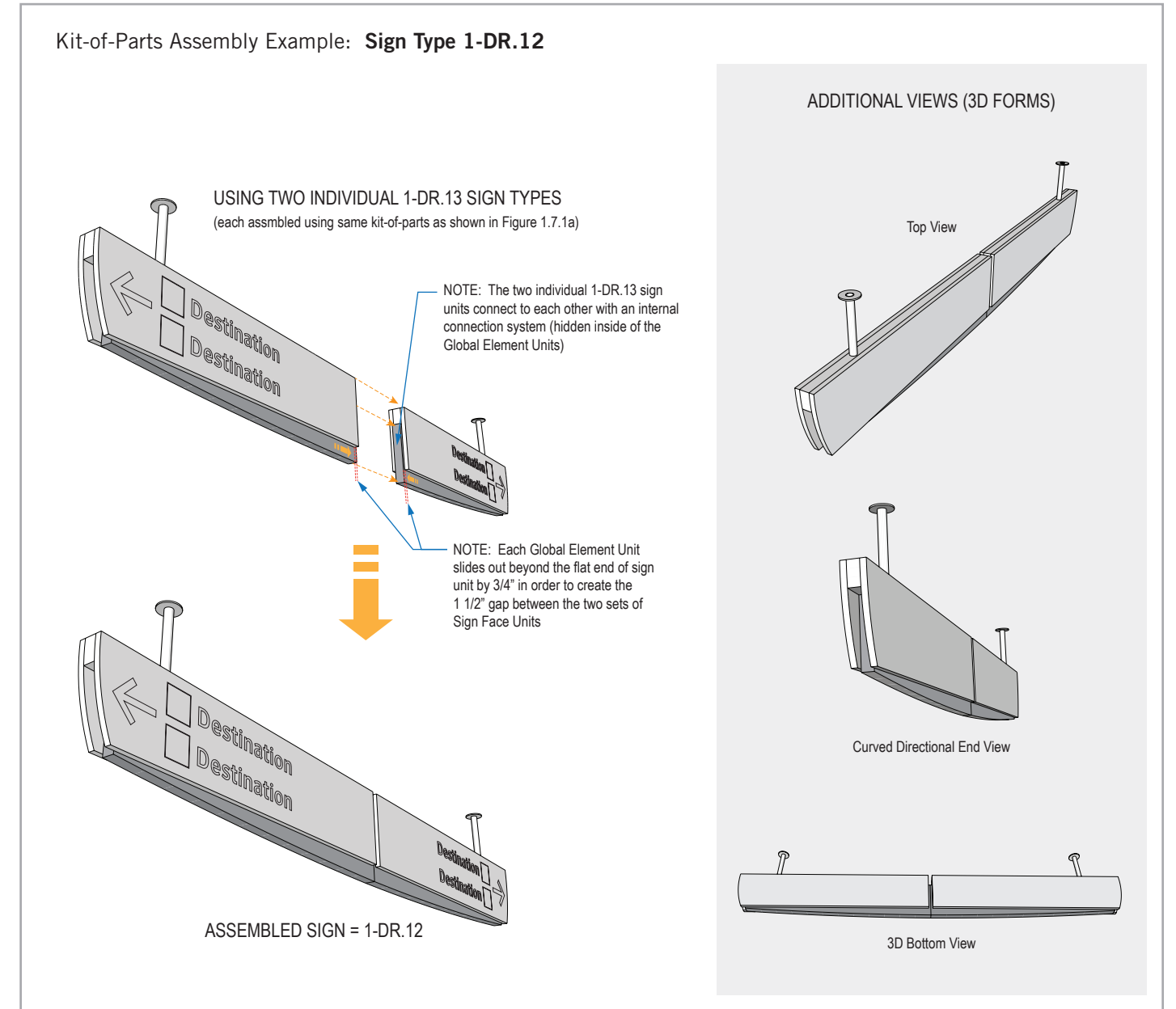
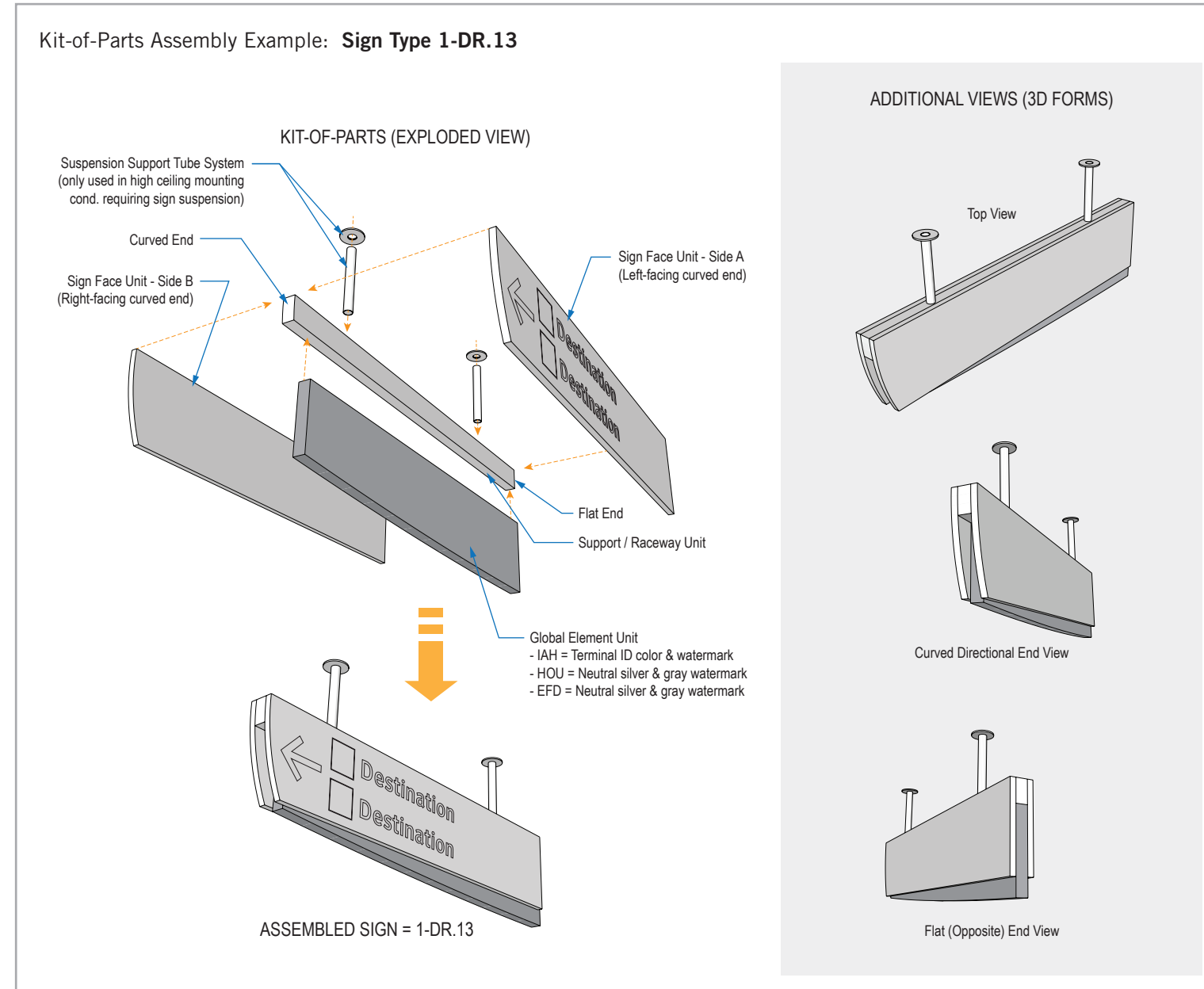


Figure 2.2.2a Kit-of-Parts Signage System - Assembly Example 1

Figure 2.2.2b Kit-of-Parts Signage System - Assembly Example 2

WAYFINDING SIGNAGE ILLUMINATION

Ambient light conditions will always have an effect on a sign's visibility and legibility. The effectiveness of a wayfinding system is greatly dependent on the ability of wayfinding traffic to decipher a sign's graphics in a multitude of varying light levels and conditions as found within an airport's interior and exterior environments. Lower ambient light levels typically have adverse effects on message comprehension, which in turn may cause increased levels of stress and distrust of the overall wayfinding system. As such, illumination considerations and implementation are an extremely critical aspect of wayfinding signage.

Methods of Illumination

There are several different types of illumination that can be used on wayfinding signage, each with their own advantages and challenges. The following are examples of typical wayfinding signage illumination types:

- Non-Illuminated:
 - Completely reliant on ambient/nearby light conditions.
 - In lower light conditions, distinguishing a sign's forms or graphics from the surrounding environment is greatly diminished (note that a sign's visibility/legibility/contrast may not meet minimum ADA requirements if ambient light conditions are too low).
 - Can be more difficult to distinguish signage forms and/or decipher graphics when located near brightly lit background environments (i.e. near exterior-facing windows during daylight hours).
 - Thinner sign profiles and generally lighter weight fabrication methods can be employed, typically resulting in lower initial fabrication costs.
- External Illumination (aka "Front-lit"):
 - Reliant on the quality, intensity and proximity of nearby light sources.
 - Forms and graphics on interior signs do not stand out from surrounding environments as well when located in higher ambient light areas.
 - Typically suffer from inconsistent visual presentation due to increased possibility of hot/dark spots across sign face/elements.
 - Requires nearby power sources be installed or in place prior to install.
 - Thinner sign profiles and generally lighter weight fabrication methods can be employed, typically resulting in lower initial fabrication costs.
- Reflective Illumination
 - Reliant on the quality, intensity, direction and distance of light sources focused specifically at the reflective face area of a sign.
 - Typically employed more frequently on vehicular signage as a means of cost effective illumination, as well as meeting associated MUTCD/TXDOT standards and requirements.
- Internal Illumination (aka "Back-lit"):
 - Not reliant on ambient light conditions.
 - Very good visibility in low or high ambient light conditions.
 - If designed and implemented properly, will typically always meet ADA sign requirements regarding visibility/legibility/contrast.
 - Greatly enhances the ability to read and distinguish wayfinding signage forms and graphics from the surrounding environment.

- Requires nearby power sources be installed or in place prior to install.
- Can be more expensive initially due to associated costs with chosen illumination technologies.
- Signage weight and profile thicknesses tend to be increased due to internal space requirements for illumination system components and added structural elements.

Illumination Guidelines and Standards - HAS Wayfinding System

HAS wayfinding signage will always utilize consistent and standardized illumination methods. This will enhance and provide holistic visibility and legibility across the overall wayfinding system, while also meeting applicable ADA and MUTCD/TXDOT requirements for wayfinding signage.

Note that at the time of this document's publication, final universal illumination implementation standards for the HAS wayfinding system are still in discussion and development with HAS. However, in the interim and for the purposes of general design intent, the following recommended guidelines and standards for illumination implementation shall be used whenever designing and/or specifying HAS wayfinding signage (*NOTE: these recommendations are based on wayfinding industry typical best practices at time of this document's publication, & may change in the future as advancement of illumination technologies occur*):

- Interior Pedestrian Signage:
 - Primary/preferred method = use internal illumination whenever possible.
 - Note that even when ambient lighting conditions are high, internal illumination still provides a benefit by making a sign's forms and graphics much more immediately visible/noticeable against competing environmental elements (see Figure 2.2.3a for conceptual design intent details and information regarding the recommended application of modern internal illumination technology within the HAS wayfinding system).
 - Modern internal LED illumination technology has several advantages associated with it when compared to conventional illumination methods (such as neon or fluorescent technologies):
 - Lower energy use and maintenance resulting in lower up-keep and power consumption costs over time.
 - Lighter weight sign fabrication methods resulting in thinner cabinet profiles/projections, which also allow for much more aesthetically attractive and less visually imposing signage.
 - When properly specified and implemented, LED edge lighting distribution is typically consistent and even across the entire sign face, while also typically eliminating hot/dark spots.
 - Heat build-up is lessened and dissipation is much more efficient, typically resulting in extended illumination life expectancy.
 - Secondary method = use non-illuminated sign fabrication
 - Note: use external illumination via nearby or dedicated lighting sources whenever possible; see Figure 2.2.3b for conceptual design intent details and information regarding the recommended non-illuminated fabrication.

- Exterior Pedestrian Signage:
 - Primary/preferred method = use internal illumination whenever possible, or where it's most beneficial and/or required (i.e. within parking garages and/or under architectural covers where ambient lighting conditions vary radically the closer/further signage is located in proximity to the projection of daylight).
 - Secondary method = use external illumination via nearby or dedicated lighting sources when internal illumination is not viable or possible.
 - Note: use reflective graphics when nearby or dedicated lighting sources are not available.
- Vehicular Signage - Roadways and Parking Garages/Lots:
 - Primary *required* method = on all overhead and roadside wayfinding signage, always use highly reflective sign face graphics by utilizing products such as 3M's DG3 line of reflective roadway sign films.
 - Specialized applications = use internal and/or external illumination on specialized signage, such as Airport property entrance gateways and architectural/building identification as applicable.
- Vehicular Signage - Curbsides:
 - Primary/preferred method = use highly reflective sign face graphics by utilizing products such as 3M's DG3 line of reflective roadway sign films.
 - Secondary method = use internal illumination for other specialized signage at terminal curbsides (i.e. curbside airline/meeting place ID).

General Illumination Requirements

- Illumination methods and usage not described here shall not be used at HAS airport properties, unless otherwise noted and approved by HAS.
- When *internal* illumination is used:
 - Illumination levels shall be uniform over the entire sign face surface.
 - No hot spots, dark spots or inconsistent/varying levels of illumination are allowed. Signs shall always be located such that the illumination level on the readable surfaces is not significantly exceeded by the ambient light or additional visible sources of light behind or in front of the sign.
- When *external* illumination is used:
 - Illumination levels on sign surfaces shall be in the 100 to 300 lux range (10 to 30 foot candles) and shall be uniform over the entire sign surface.
 - No hot spots, dark spots or inconsistent/varying levels of illumination are allowed. Signs shall always be located such that the illumination level on the readable surfaces is not significantly exceeded by the ambient light or additional sources of light behind or in front of the sign.
 - Elements casting illumination from external sources (i.e. external attachments/housings/etc. for directed lighting) shall not block visibility of the sign or cast distracting shadows upon the sign's readable areas.
- When *non-illuminated* is used:
 - When located near other internally illuminated signs, Terminal ID colors on non-illuminated signs will require custom color matched paint to create color consistency across all wayfinding signage.

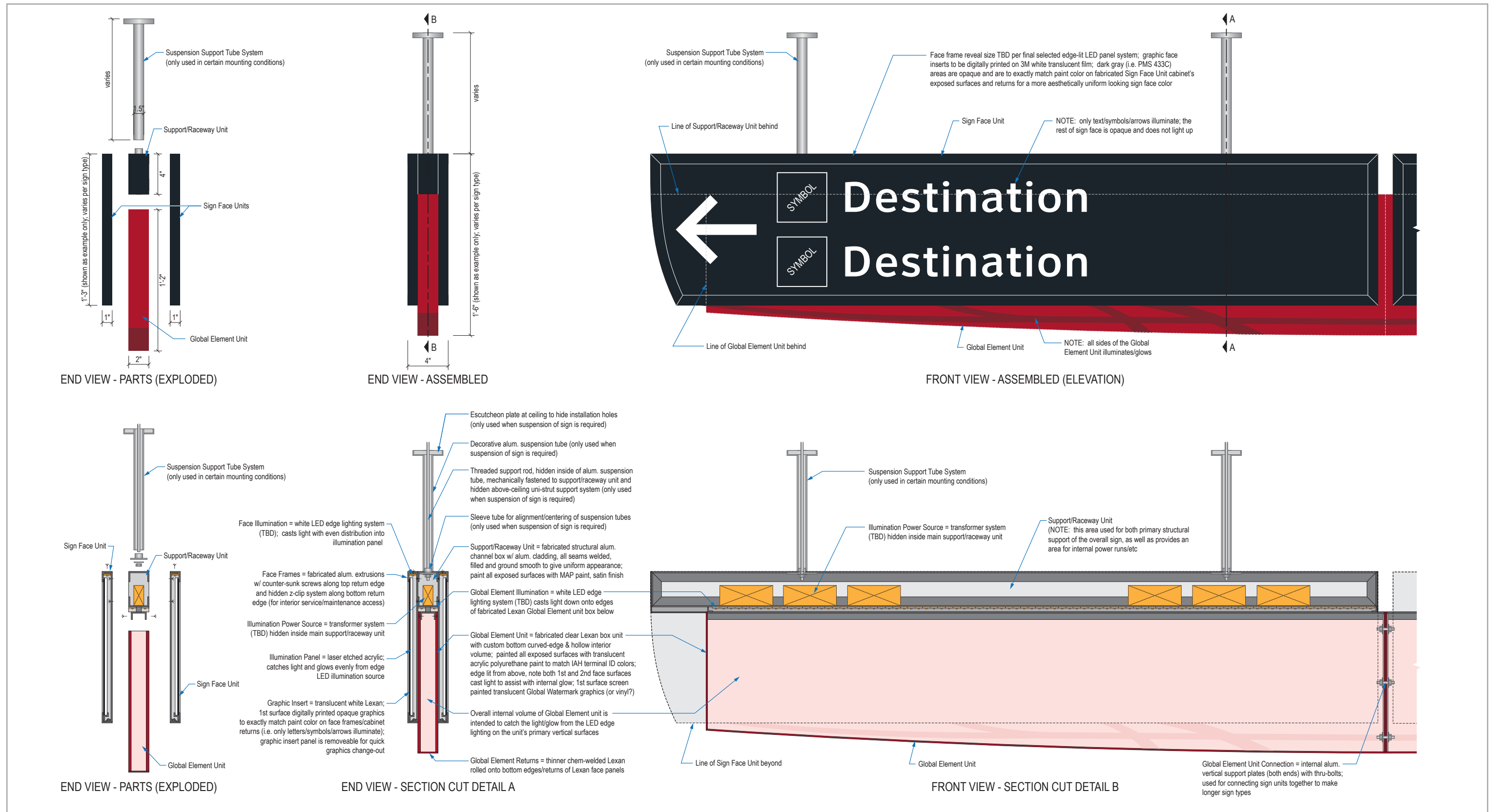


Figure 2.2.3a Internally Illuminated Wayfinding Signage: Typical Conceptual Fabrication Design Intent Detail Example (Interior Signs)

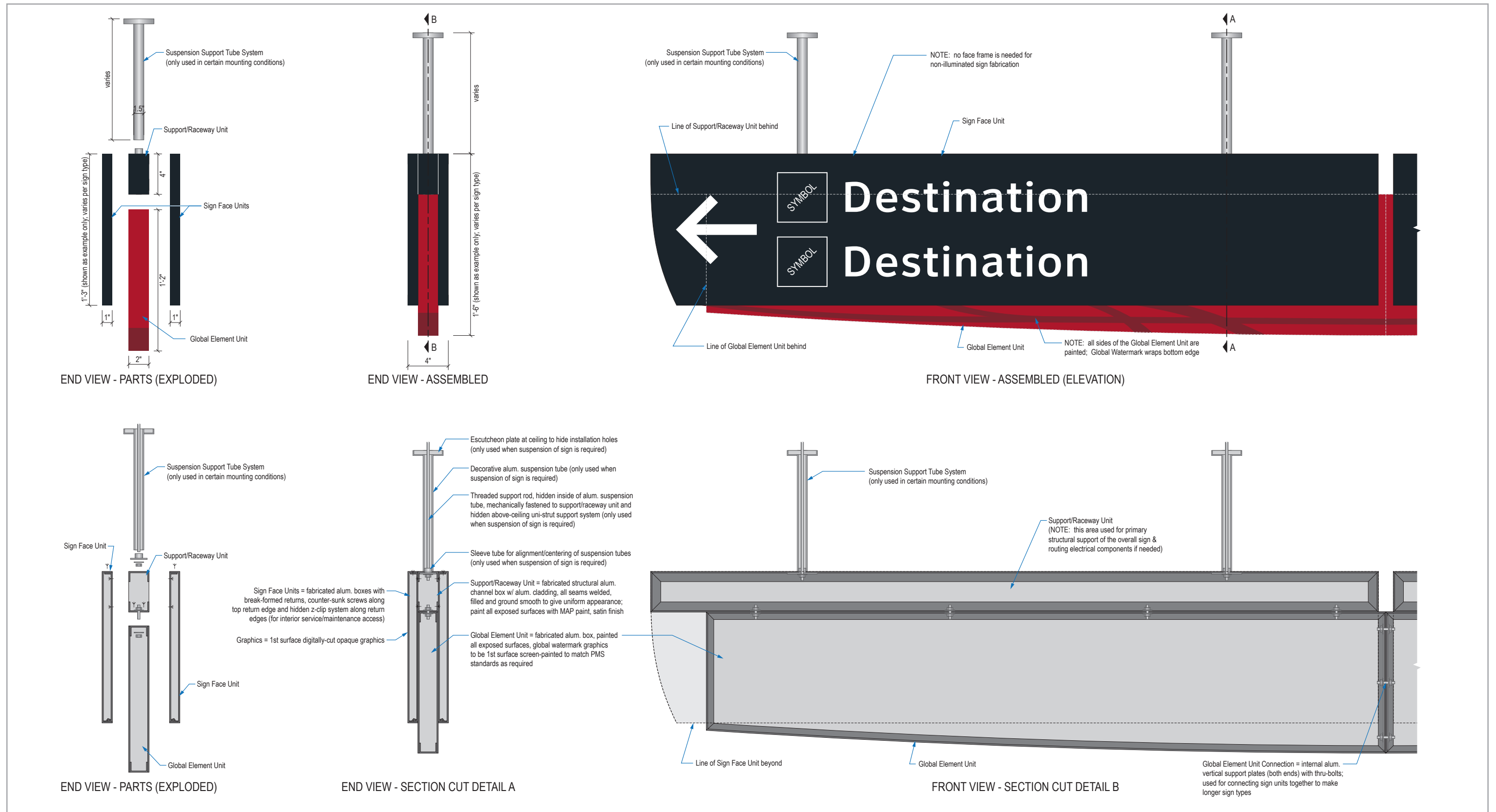


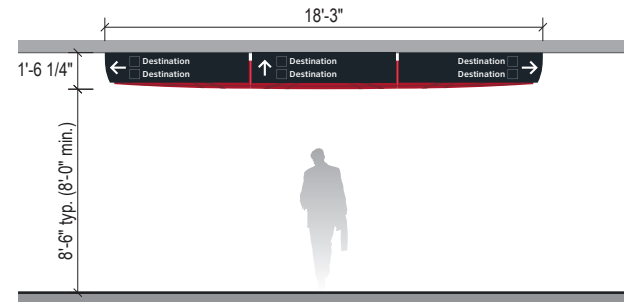
Figure 2.2.3b Non-Illuminated Wayfinding Signage: Typical Conceptual Fabrication Design Intent Detail Example (Interior Signs)

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

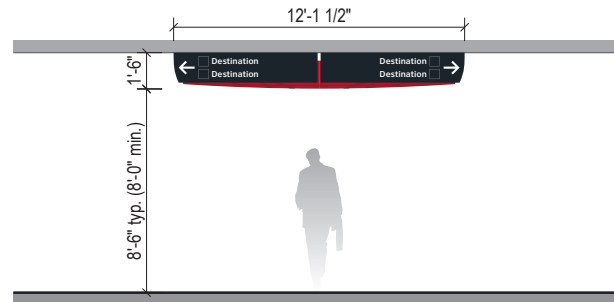
NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.00 to 1-DR.09 = Directionals: CEILING FLUSH Mount (Top Flush)

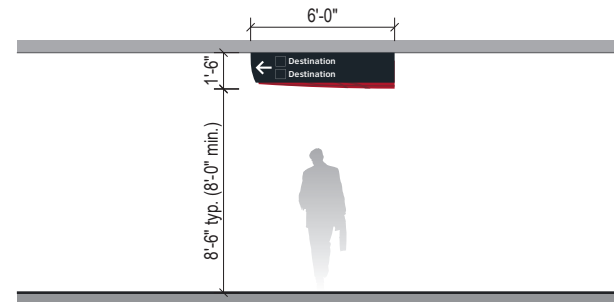
3" Text



1-DR.01 3-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"; 2 Sides

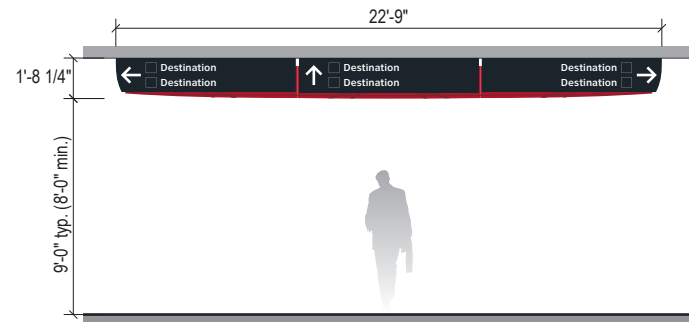


1-DR.02 2-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"; 2 Sides

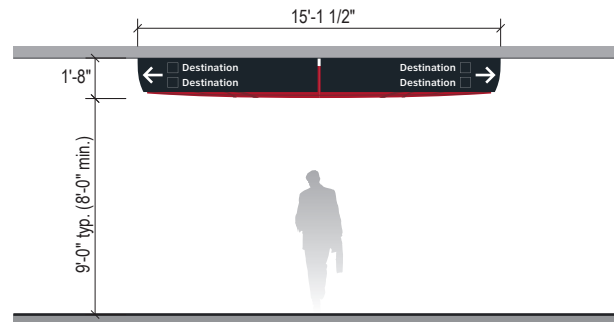


1-DR.03 1-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"; 2 Sides

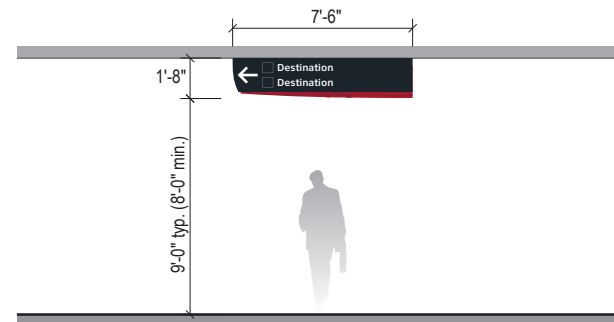
3.5" Text



1-DR.01b Med. 3-way Ceiling Flush Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 3 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

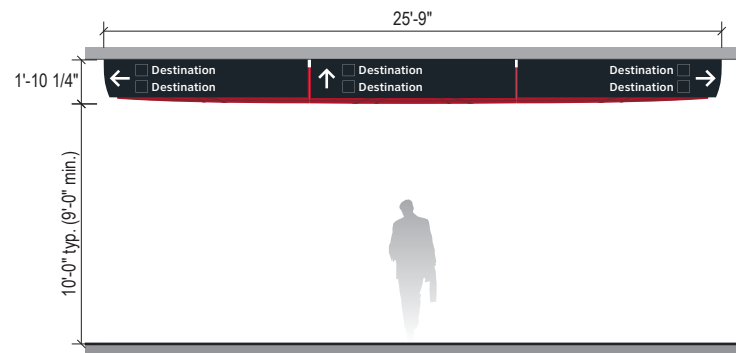


1-DR.02b Med. 2-way Ceiling Flush Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

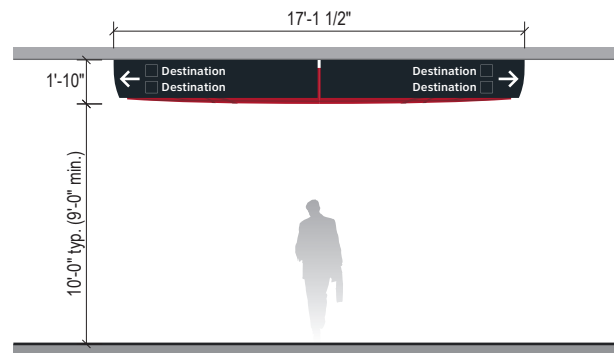


1-DR.03b Med. 1-way Ceiling Flush Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

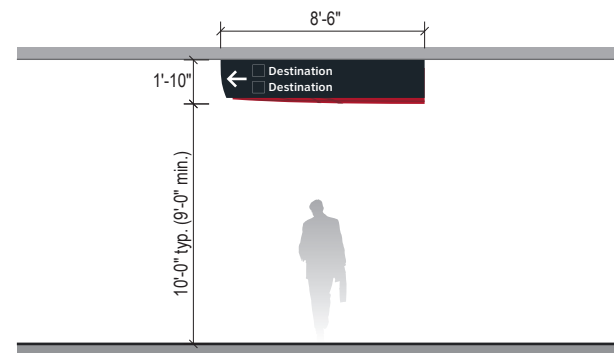
4" Text



1-DR.01c Large 3-way Ceiling Flush Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht./view dist.
 - 3 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 6"; 2 Sides



1-DR.02c Large 2-way Ceiling Flush Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 6"; 2 Sides

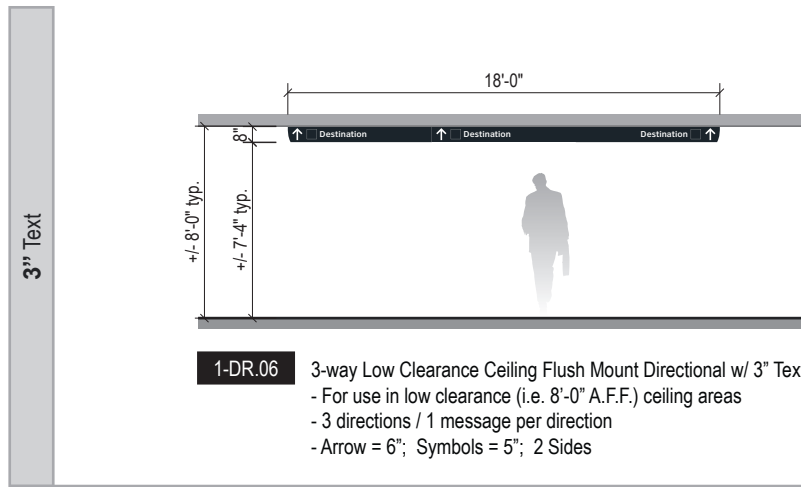


1-DR.03c Large 1-way Ceiling Flush Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 6"; 2 Sides

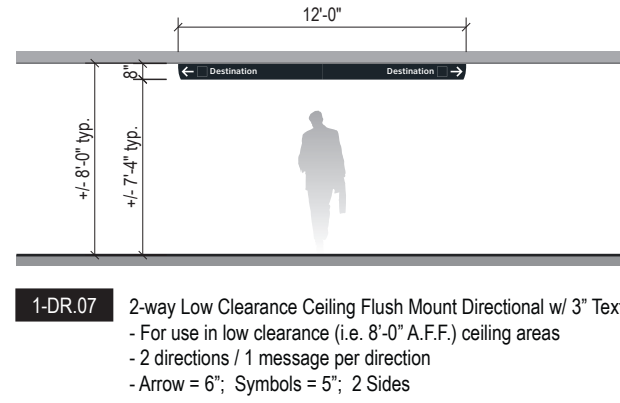
Series 1: Terminal / Concourse - **Directionals** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

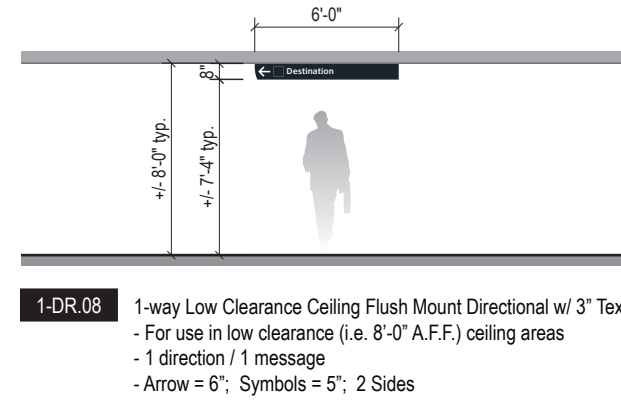
1-DR.00 to 1-DR.09 = Directionals: **CEILING FLUSH** Mount (Top Flush)



1-DR.06 3-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 3 directions / 1 message per direction
 - Arrow = 6"; Symbols = 5"; 2 Sides



1-DR.07 2-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 2 directions / 1 message per direction
 - Arrow = 6"; Symbols = 5"; 2 Sides



1-DR.08 1-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 1 direction / 1 message
 - Arrow = 6"; Symbols = 5"; 2 Sides

1-DR.10 to 1-DR.19 = Directionals: **CEILING SUSPENDED** Mount



1-DR.10d Large Ceiling Suspended Ticketing Lobby Directional
 - 4 directions; message categories per direction vary
 - Text: Header = 4"; Gates = 5"; Airlines = 3.5"
 - Arrow = 10"
 - Symbols: Header = 6"; Gates = 8"
 - 2 Sides

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.10 to 1-DR.19 = Directionals: CEILING SUSPENDED Mount

3" Text			
	<p>1-DR.11 3-way Ceiling Suspended Directional w/ 3" Text</p> <ul style="list-style-type: none"> - Standard minimum size overhead directional - 3 directions / 1-2 messages per direction - Arrow = 8"; Symbols = 5"; 2 Sides 	<p>1-DR.12 2-way Ceiling Suspended Directional w/ 3" Text</p> <ul style="list-style-type: none"> - Standard minimum size overhead directional - 2 directions / 1-2 messages per direction - Arrow = 8"; Symbols = 5"; 2 Sides 	<p>1-DR.13 1-way Ceiling Suspended Directional w/ 3" Text</p> <ul style="list-style-type: none"> - Standard minimum size overhead directional - 1 direction / 1-2 messages - Arrow = 8"; Symbols = 5"; 2 Sides
3.5" Text			
	<p>1-DR.11b Med. 3-way Ceiling Suspended Mount Directional w/ 3.5" Text</p> <ul style="list-style-type: none"> - Med. size variant with 3.5" text for increased mounting ht./view dist. - 3 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 5.25"; 2 Sides 	<p>1-DR.12b Med. 2-way Ceiling Suspended Mount Directional w/ 3.5" Text</p> <ul style="list-style-type: none"> - Med. size variant with 3.5" text for increased mounting ht./view dist. - 2 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 5.25"; 2 Sides 	<p>1-DR.13b Med. 1-way Ceiling Suspended Mount Directional w/ 3.5" Text</p> <ul style="list-style-type: none"> - Med. size variant with 3.5" text for increased mounting ht./view dist. - 1 direction / 1-2 messages - Arrow = 10"; Symbols = 5.25"; 2 Sides
4" Text			
	<p>1-DR.11c Large 3-way Ceiling Suspended Directional w/ 4" Text</p> <ul style="list-style-type: none"> - Large size variant with 4" text for increased mounting ht./view dist. - 3 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 6"; 2 Sides 	<p>1-DR.12c Large 2-way Ceiling Suspended Directional w/ 4" Text</p> <ul style="list-style-type: none"> - Large size variant with 4" text for increased mounting ht./view dist. - 2 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 6"; 2 Sides 	<p>1-DR.13c Large 1-way Ceiling Suspended Directional w/ 4" Text</p> <ul style="list-style-type: none"> - Large size variant with 4" text for increased mounting ht./view dist. - 1 direction / 1-2 messages - Arrow = 10"; Symbols = 6"; 2 Sides

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.20 to 1-DR.29 = Directional: SOFFIT / WALL Mount

3" Text	<p>1-DR.21 3-way Soffit/Wall Mount Directional w/ 3" Text - Standard minimum size overhead directional - 3 directions / 1-2 messages per direction - Arrow = 8"; Symbols = 5"; 1 Side</p>	<p>1-DR.22 2-way Soffit/Wall Mount Directional w/ 3" Text - Standard minimum size overhead directional - 2 directions / 1-2 messages per direction - Arrow = 8"; Symbols = 5"; 1 Side</p>	<p>1-DR.23 1-way Soffit/Wall Mount Directional w/ 3" Text - Standard minimum size overhead directional - 1 direction / 1-2 messages - Arrow = 8"; Symbols = 5"; 1 Side</p>	<p>1-DR.23-r Right-Facing Variant</p>
3.5" Text	<p>1-DR.21b Med. 3-way Soffit/Wall Mount Directional w/ 3.5" Text - Med. size variant with 3.5" text for increased mounting ht./view dist. - 3 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 5.25"; 1 Side</p>	<p>1-DR.22b Med. 2-way Soffit/Wall Mount Directional w/ 3.5" Text - Med. size variant with 3.5" text for increased mounting ht./view dist. - 2 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 5.25"; 1 Side</p>	<p>1-DR.23b Med. 1-way Soffit/Wall Mount Directional w/ 3.5" Text - Med. size variant with 3.5" text for increased mounting ht./view dist. - 1 direction / 1-2 messages - Arrow = 10"; Symbols = 5.25"; 1 Side</p>	<p>1-DR.23b-r Right-Facing Variant</p>
4" Text	<p>1-DR.21c Large 3-way Soffit/Wall Mount Directional w/ 4" Text - Large size variant with 4" text for increased mounting ht./view dist. - 3 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 6"; 1 Side</p>	<p>1-DR.22c Large 2-way Soffit/Wall Mount Directional w/ 4" Text - Large size variant with 4" text for increased mounting ht./view dist. - 2 directions / 1-2 messages per direction - Arrow = 10"; Symbols = 6"; 1 Side</p>	<p>1-DR.23c Large 1-way Soffit/Wall Mount Directional w/ 4" Text - Large size variant with 4" text for increased mounting ht./view dist. - 1 direction / 1-2 messages - Arrow = 10"; Symbols = 6"; 1 Side</p>	<p>1-DR.23c-r Right-Facing Variant</p>

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.20 to 1-DR.29 = Directional: SOFFIT / WALL Mount

1-DR.23d 1-way Soffit/Wall Mount Ticketing Lobby Directional
 - 1 direction / 4 messages
 - Text: Header = 4"; Dest. = 3.5"
 - Arrow = 10"
 - Symbols: Header = 6"; Dest. = 5.25"
 - 1 Side

1-DR.23d-r Right-Facing Variant

1-DR.25d 1-way Soffit/Wall Mount Airline/Gate Directional
 - 2 directions; message categories per direction vary
 - Text: Header = 4"; Gates = 4"; Airlines = 3.5"
 - Arrow = 10"
 - Symbols: Header = 6"; Gates = 6"
 - 1 Side

1-DR.25d-r Right-Facing Variant

1-DR.30 to 1-DR.39 = Directional: WALL Mount - Plaques

(Scale: 1/2" = 1'-0")

1-DR.31 Wall Mount Plaque Directional w/ 1/2" text
 - 1-3 directions / multiple message variations
 - Arrow = 2"; Symbols = 1"; 1 Side

1-DR.32 Large Wall Mount Plaque Directional w/ 1.5" text
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"; 1 Side

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.40 to 1-DR.49 = Directional: FLAG / CANTILEVER Mount

1-DR.42 1-way Flag Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"; 2 Sides

1-DR.46 2-way Cantilever Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"; 2 Sides

1-DR.42b Med. 1-way Flag Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

1-DR.46b Med. 2-way Cantilever Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

1-DR.42c Large 1-way Flag Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 6"; 2 Sides

1-DR.46c Large 2-way Cantilever Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 6"; 2 Sides

1-DR.50 to 1-DR.59 = Directional: FLOOR / POST Mount

1-DR.52b Med. 2-way Floor/Post Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

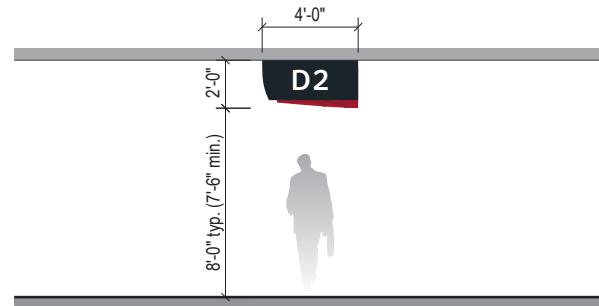
1-DR.53b Med. 1-way Floor/Post Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

1-DR.58 Floor Mount Directional w/ 1.5" text
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"
 - 2 Sides

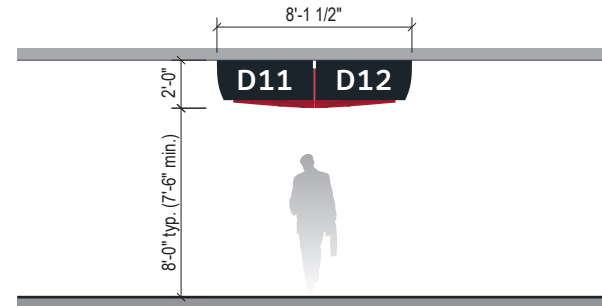
Series 1: Terminal / Concourse - Identification (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

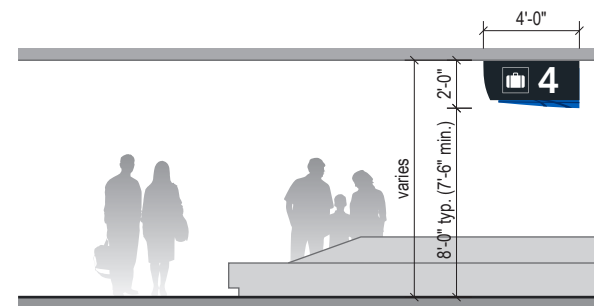
1-ID.00 to 1-ID.09 = Identification: CEILING FLUSH Mount (Top Flush)



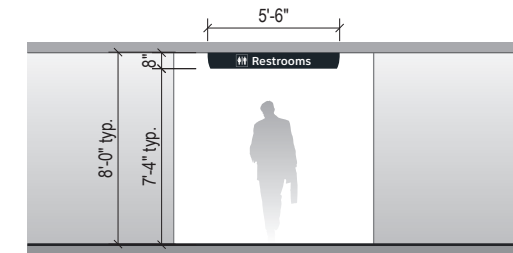
1-ID.02 Ceiling Flush Mount Gate ID w/ 1 Number
 - Text = 10"
 - 2 Sides



1-ID.02b Ceiling Flush Mount Gate ID w/ 2 Numbers
 - Text = 10"
 - 2 Sides

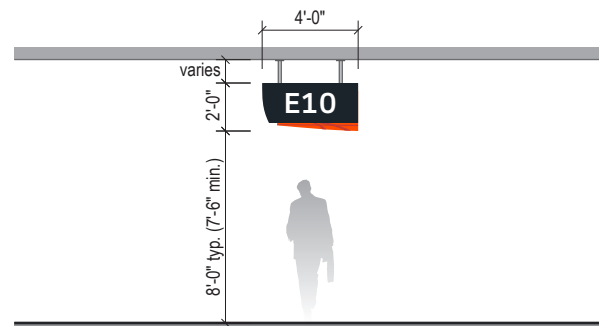


1-ID.05 Ceiling Flush Mount Baggage Claim Carousel ID
 - Symbol = 1'-1"; Text = 1'-1"
 - 2 Sides

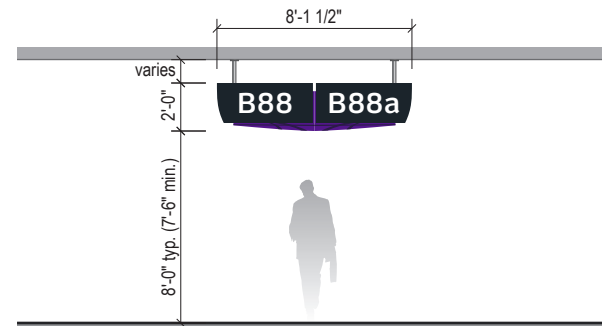


1-ID.07b Low Clearance Ceiling Flush Mount Entry ID
 - Symbol = 6"; Text = 4"
 - 2 Sides

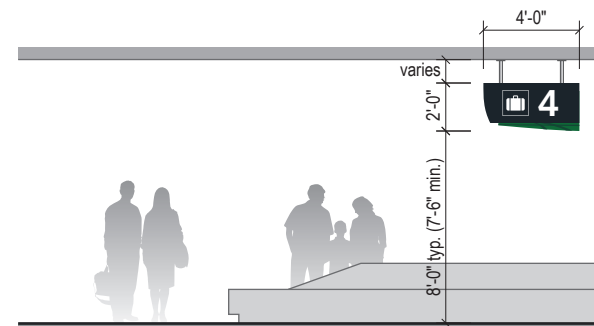
1-ID.10 to 1-ID.19 = Identification: CEILING SUSPENDED Mount



1-ID.12 Ceiling Suspended Gate ID w/ 1 Number
 - Text = 10"
 - 2 Sides



1-ID.12b Ceiling Suspended Gate ID w/ 2 Numbers
 - Text = 10"
 - 2 Sides

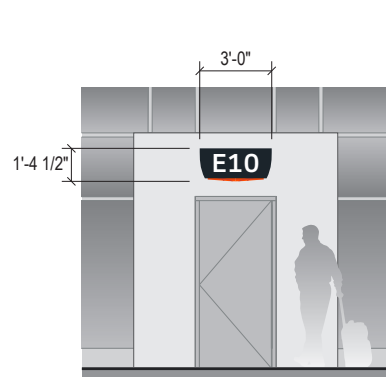


1-ID.15 Ceiling Suspended Baggage Claim Carousel ID
 - Symbol = 1'-1"; Text = 1'-1"
 - 2 Sides

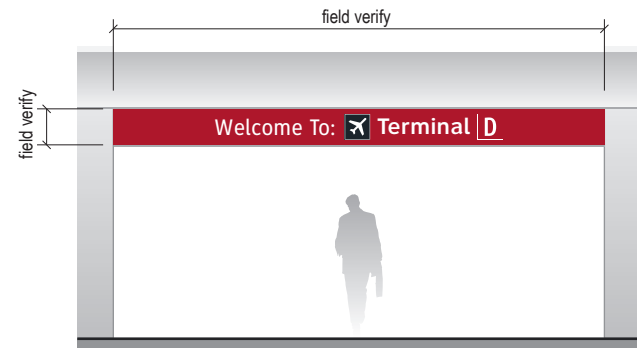
Series 1: Terminal / Concourse - Identification (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

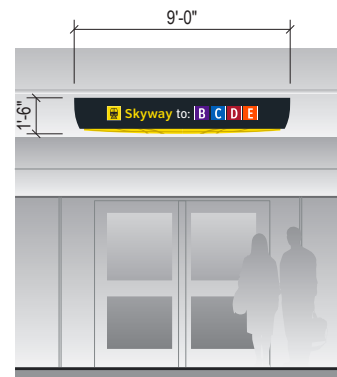
1-ID.20 to 1-ID.29 = Identification: SOFFIT / WALL Mount



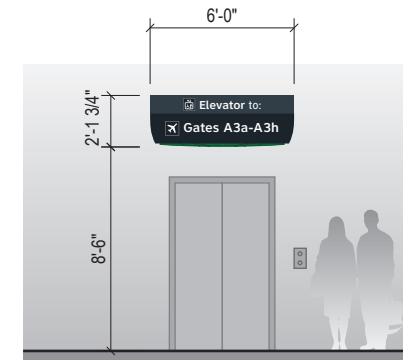
1-ID.21 Soffit/Wall Mount Gate Door ID
- Text = 9"
- 1 Side



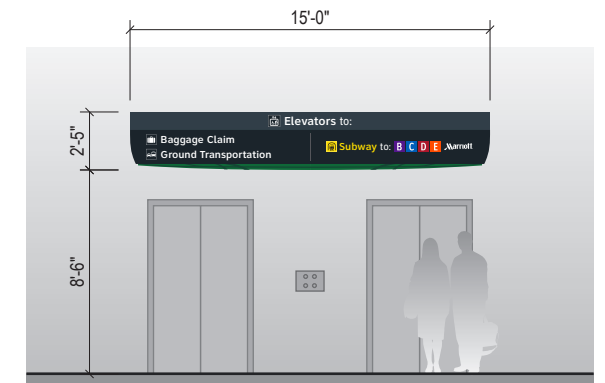
1-ID.23 Soffit/Wall Mount Terminal Entrance ID
- Text = TBD per terminal entrance conditions
- Symbol = TBD per terminal entrance conditions
- 1 Side



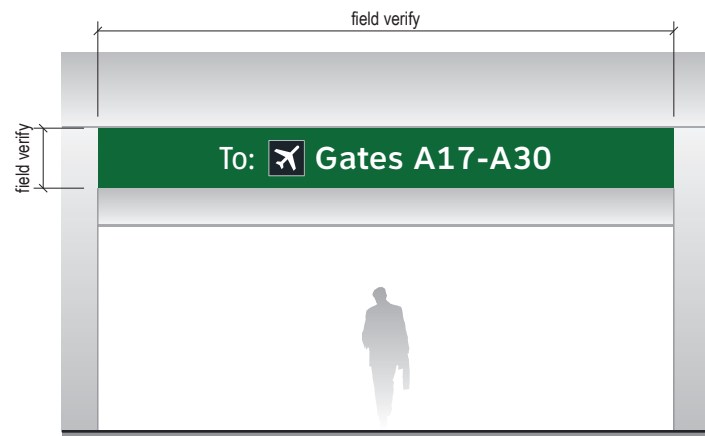
1-ID.24 Soffit/Wall Mount Skyway Train Door ID
- Text = 4.5"; Symbols = 7"
- 1 Side



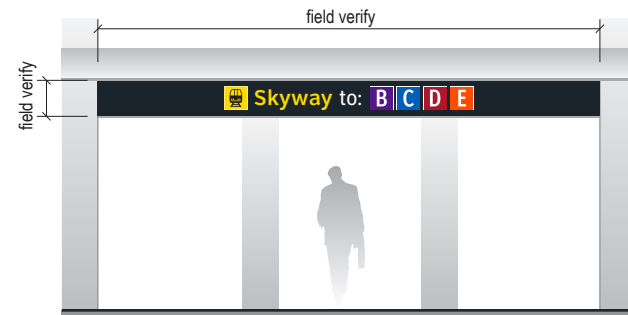
1-ID.25b Med. Soffit/Wall Mount Elevator ID
- Text: Header = 4"; Dest. = 4.5"
- Symbols: Header = 6"; Dest. = 7"
- 1 Side



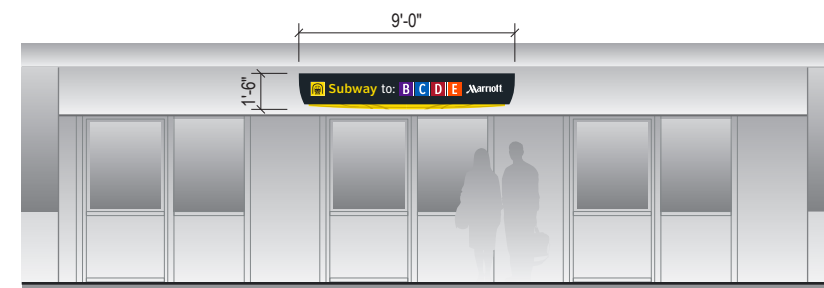
1-ID.26b Large Soffit/Wall Mount Elevator ID
- Text: Header = 4"; Dest. = 3.5"
- Symbols: Header = 6"; Dest. = 5.25"
- 1 Side



1-ID.27 Soffit/Wall Mount Security Checkpoint Entrance ID
- Text = TBD per checkpoint entrance conditions
- Symbol = TBD per checkpoint entrance conditions
- 1 Side



1-ID.28 Soffit/Wall Mount Skyway Station Entrance ID
- Text = TBD per Skyway station entrance conditions
- Symbol = TBD per Skyway station entrance conditions
- 1 Side



1-ID.28d Soffit/Wall Mount Subway Train Door ID
- Text = 4.5"; Symbols = 7"
- 1 Side

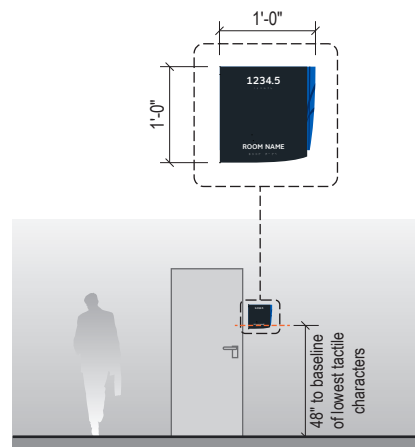


1-ID.29 Wall Mount Level ID at Elevators
- 1 Side

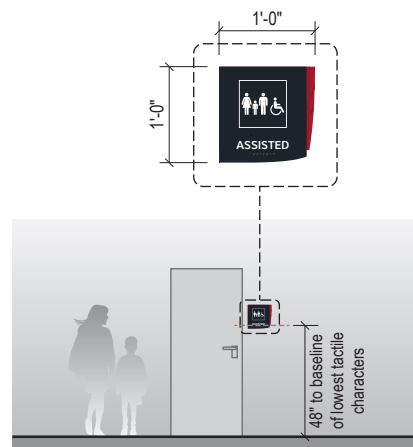
Series 1: Terminal / Concourse - Identification (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

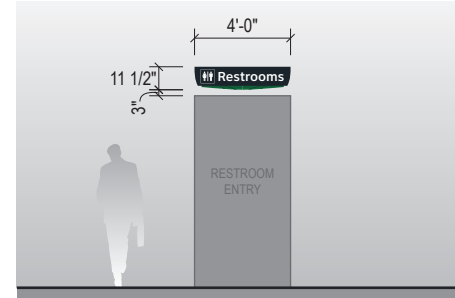
1-ID.30 to 1-ID.39 = Identification: WALL Mount - ADA Plaques & Restroom ID



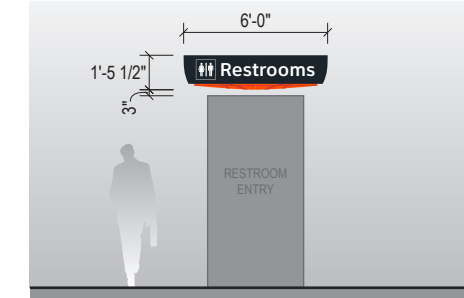
1-ID.30 Wall Mount ADA Tactile General Room ID
 - All mounting, text/graphic sizing & tactile elements per ADA/TAS
 - 1 Side



1-ID.31 Wall Mount ADA Tactile Restroom ID
 - All mounting, text/graphic sizing & tactile elements per ADA/TAS
 - 1 Side

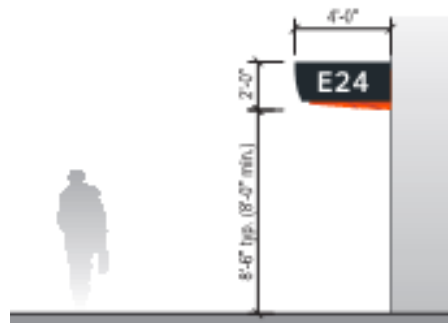


1-ID.35 Soffit/Wall Mount Restroom Entry ID
 - Text = 4.5"
 - Symbol = 7"
 - 1 Side

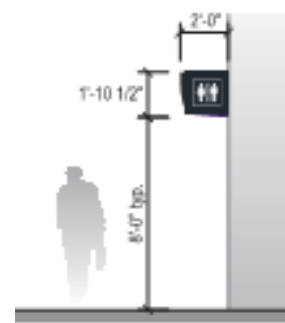


1-ID.35b Large Soffit/Wall Mount Restroom Entry ID
 - Text = 6.5"
 - Symbol = 10"
 - 1 Side

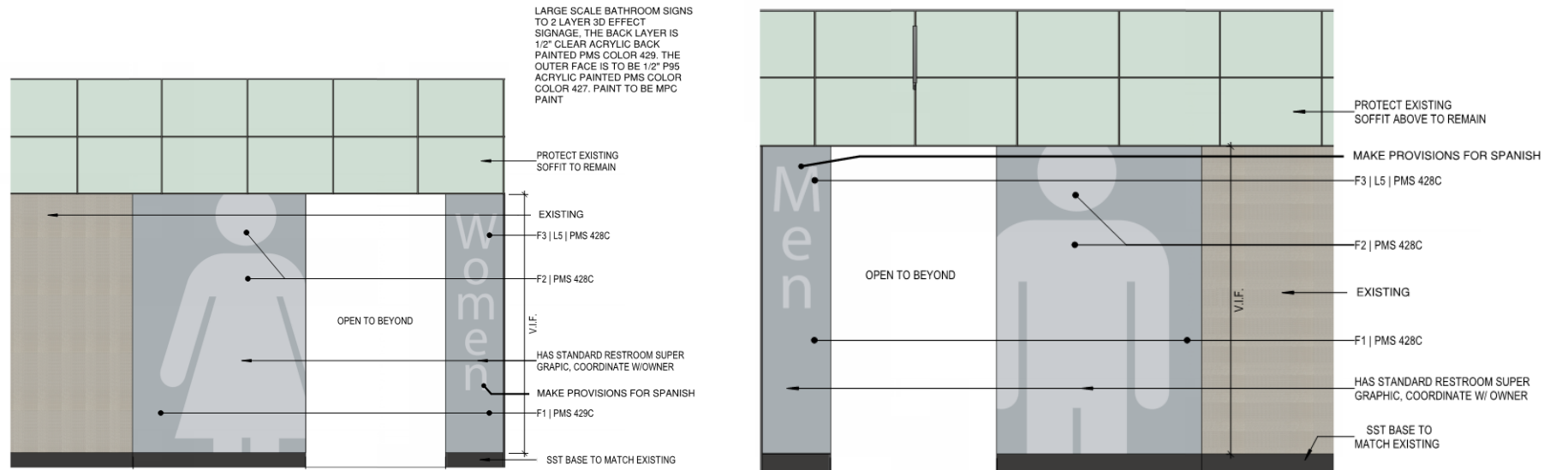
1-ID.40 to 1-ID.49 = Identification: FLAG Mount



1-ID.42 Flag Mount Gate ID w/ 1 Number
 - Text = 10"
 - 2 Sides



1-ID.43 Med. Flag Mount Restroom ID
 - Symbol = 1'-2"
 - 2 Sides

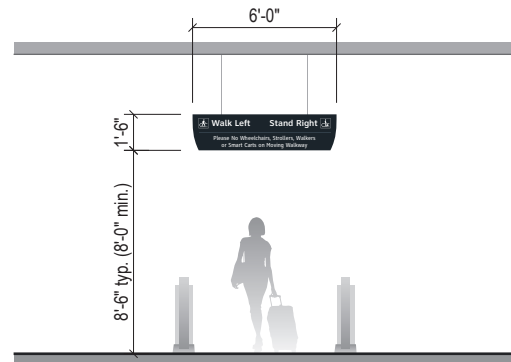


Typical Restroom Graphics

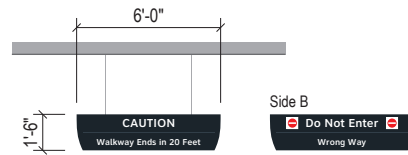
Series 1: Terminal / Concourse - **Informational** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-IN.10 to 1-IN.19 = Informational: **CEILING SUSPENDED** Mount

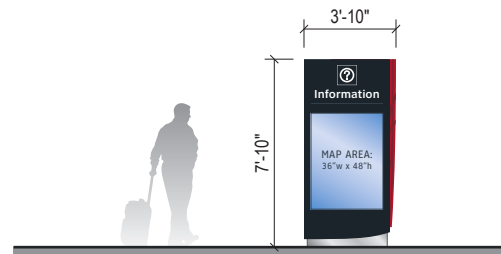


1-IN.16 Moving Walkway Informational
 - Symbols = 5"; Text = 3" and 2"
 - 2 Sides



1-IN.16b Moving Walkway Caution Informational
 - Symbols = 6"; Text = 4" and 3"
 - 2 Sides

1-IN.50 to 1-IN.59 = Informational: **FLOOR** Mount

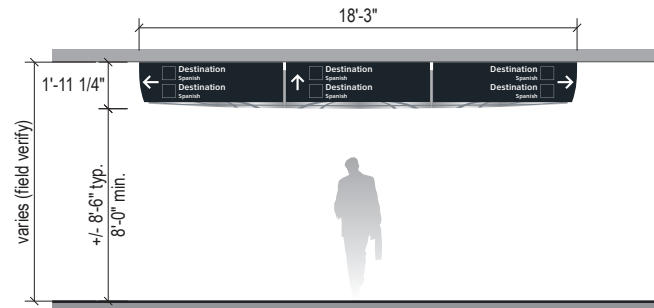


1-IN.50 Floor Mount Information Directory - Portrait Config.
 - Directory map artwork area = 36" w x 48" h
 - Header Symbol = 10"; Header Text = 4"
 - 1-2 Sides

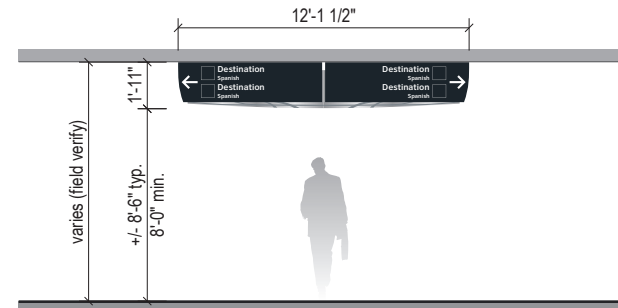
Series 2: CBP Areas - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

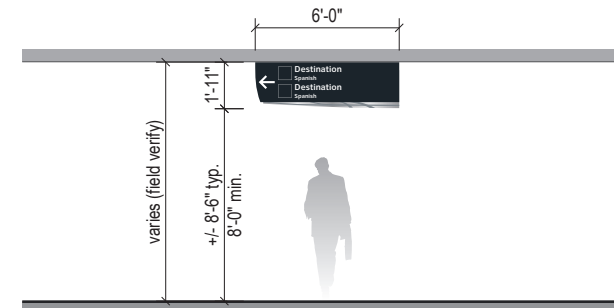
2-DR.00 to 2-DR.09 = Directionals: CEILING FLUSH Mount (Top Flush)



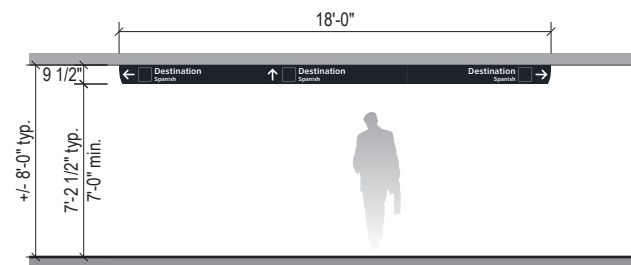
2-DR.01-S 3-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



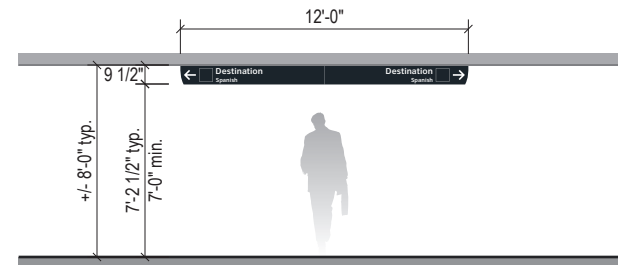
2-DR.02-S 2-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



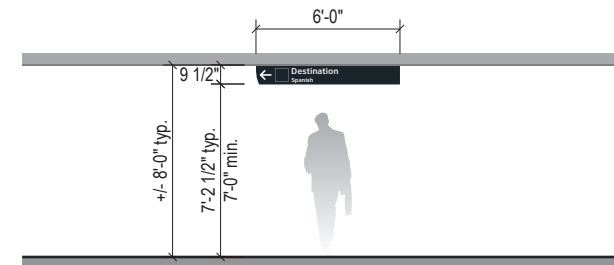
2-DR.03-S 1-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



2-DR.06-S 3-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 3 directions / 1 message per direction
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides



2-DR.07-S 2-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 2 directions / 1 message per direction
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides

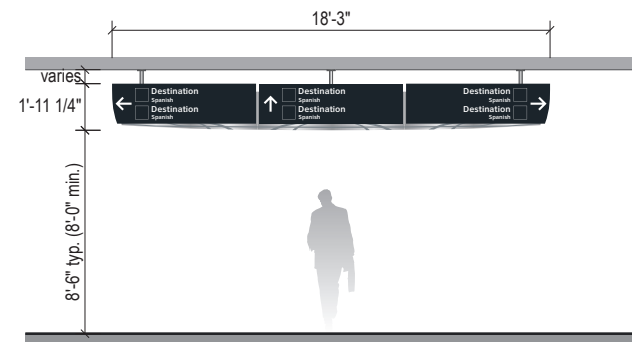


2-DR.08-S 1-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 1 direction / 1 message
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides

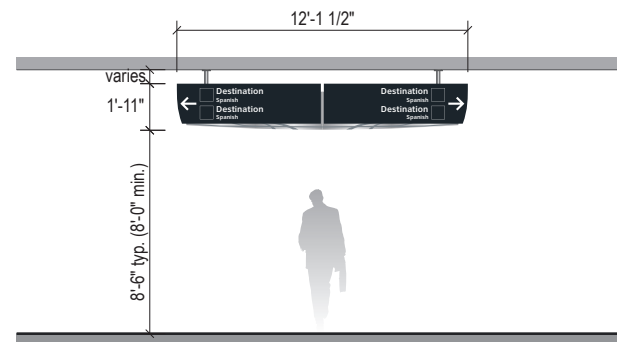
Series 2: CBP Areas - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

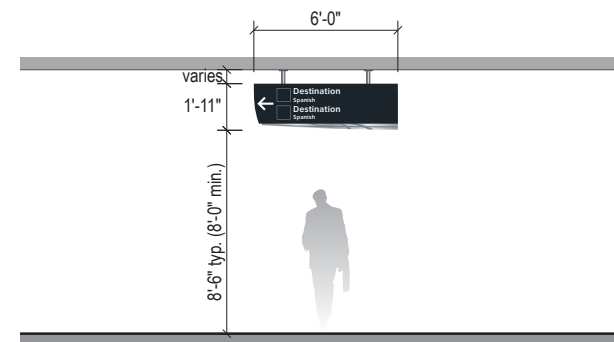
2-DR.10 to 2-DR.19 = Directionals: CEILING SUSPENDED Mount



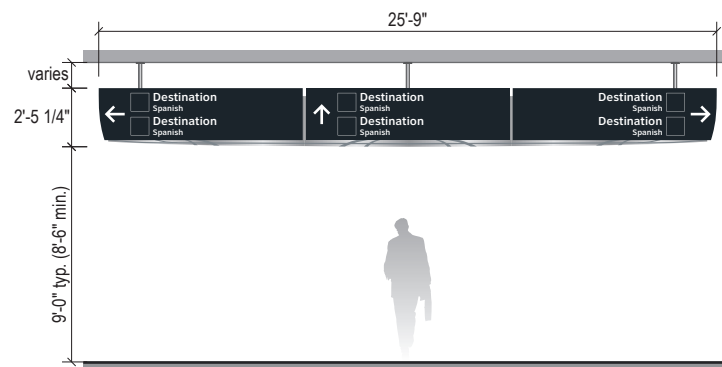
2-DR.11-S 3-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 3 directions / 2-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



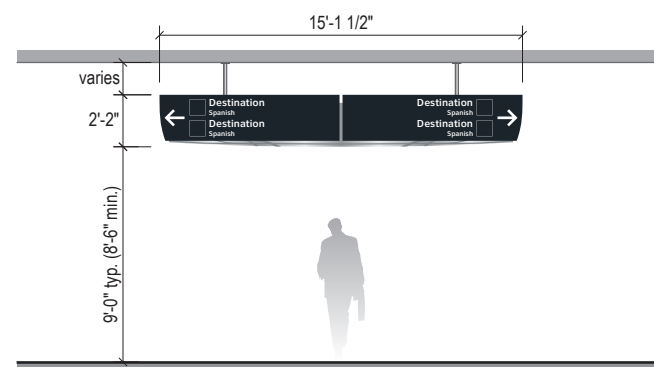
2-DR.12-S 2-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 2 directions / 2-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



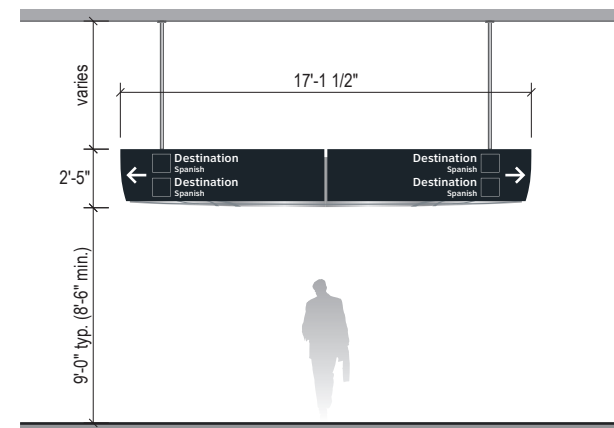
2-DR.13-S 1-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 1 direction / 2-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



2-DR.11c-S Large 3-way Ceiling Suspended Directional w/ 4" Text and 2.75" Supplemental Spanish Text
 - Large size variant with 4" text for increased mounting ht. and viewing distances
 - 3 directions / 2-2 messages per direction
 - Arrow = 10"; Symbols = 9.25"
 - 2 Sides



2-DR.12b-S Med. 2-way Ceiling Suspended Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text
 - Medium size variant with 3.5" text for increased mounting ht. and viewing distances
 - 2 directions / 2-2 messages per direction
 - Arrow = 10"; Symbols = 8"
 - 1 Side



2-DR.12c-S Large 2-way Ceiling Suspended Directional w/ 4" Text and 2.75" Supplemental Spanish Text
 - Large size variant with 4" text for increased mounting ht. and viewing distances
 - 2 directions / 2-2 messages per direction
 - Arrow = 10"; Symbols = 9.25"
 - 2 Sides

Series 2: CBP Areas - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

2-DR.20 to 2-DR.29 = Directional: SOFFIT / WALL Mount

2-DR.21b-S MEDIUM 3-way Soffit/Wall Mount Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text

- Medium size variant with 3.5" text for increased mounting ht. and viewing distances
- 3 directions / 2-2 messages per direction
- Arrow = 10"; Symbols = 8"
- 1 Side

2-DR.22-S 2-way Soffit/Wall Mount Directional w/ 3" Text and 2" Supplemental Spanish Text

- Standard minimum size overhead directional
- 2 directions / 2-2 messages per direction
- Arrow = 8"; Symbols = 6.75"
- 1 Side

2-DR.22b-S MEDIUM 2-way Soffit/Wall Mount Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text

- Medium size variant with 3.5" text for increased mounting ht. and viewing distances
- 3 directions / 2-2 messages per direction
- Arrow = 10"; Symbols = 8"
- 1 Side

2-DR.26-S Soffit/Wall Mount Directional w/ CBP Exit Message

- 1 direction / 1-2 messages
- Arrow = 8"; Symbols = 6.75"
- 1 Side

2-DR.40 to 2-DR.49 = Directional: FLAG Mount

2-DR.42-S 2-way Flag Mount Directional w/ 3" Text and 2" Supplemental Spanish Text

- Standard minimum size overhead directional
- 1 direction / 2-2 messages
- Arrow = 8"; Symbols = 6.75"
- 2 Sides

2-DR.42c-S LARGE 2-way Flag Mount Directional w/ 4" Text and 2.75" Supplemental Spanish Text

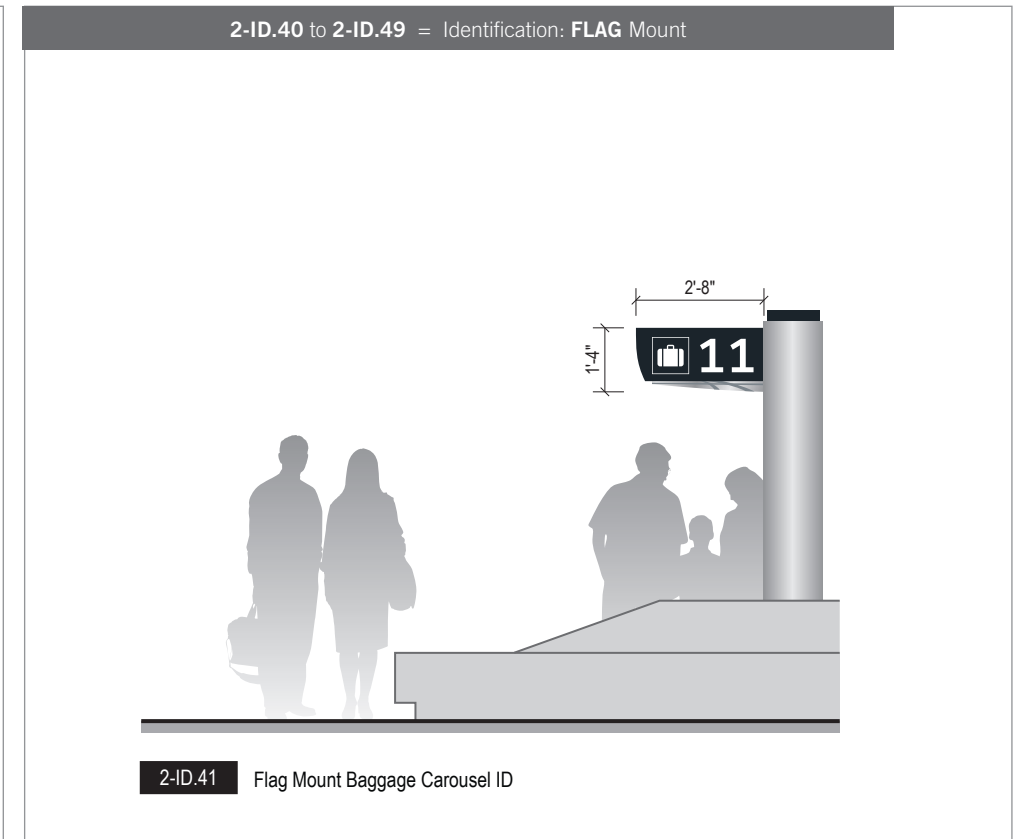
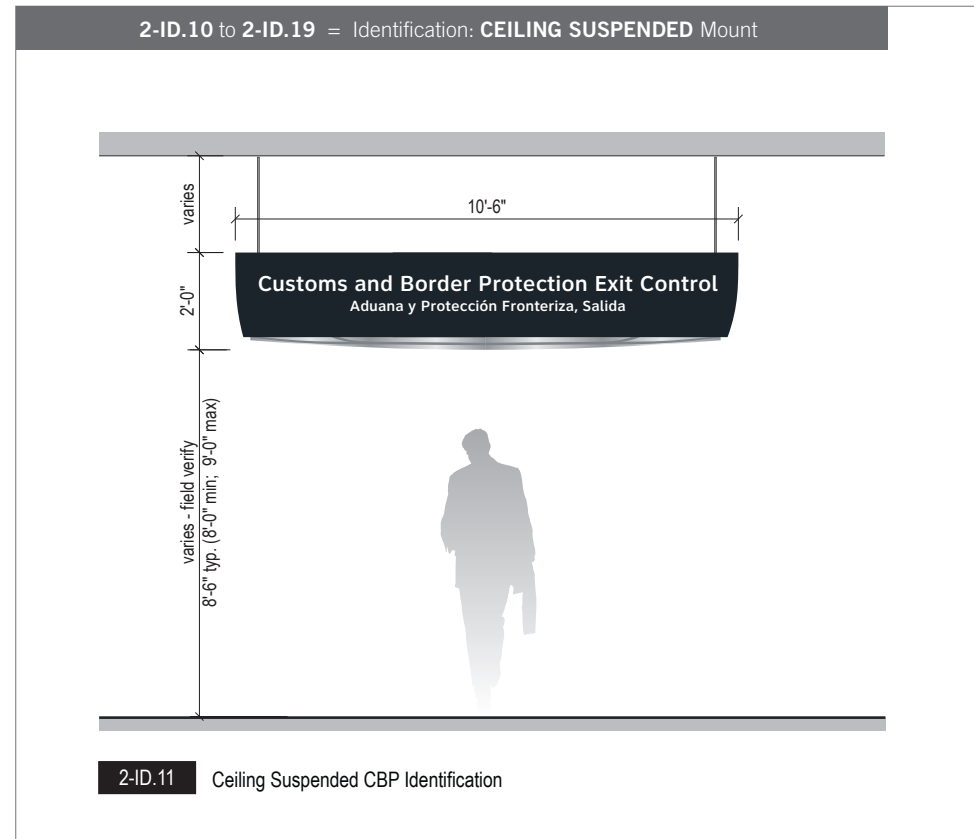
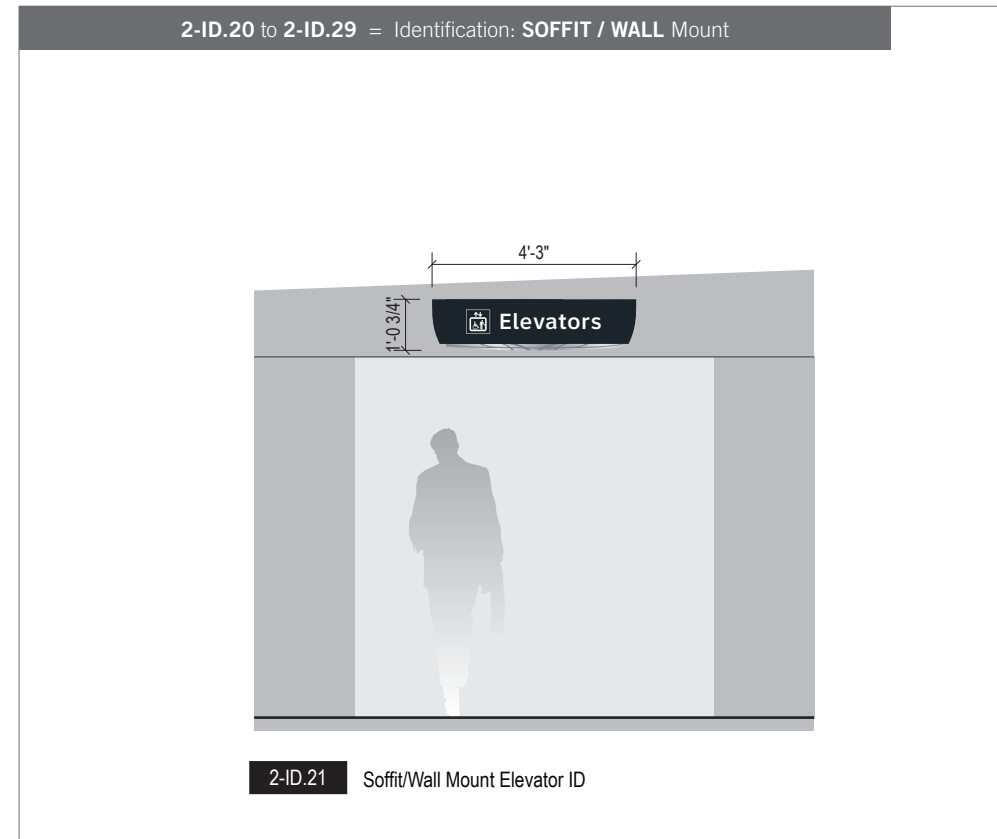
- Large size variant with 4" text for increased mounting ht. and viewing distances
- 1 direction / 2-2 messages
- Arrow = 10"; Symbols = 9.25"
- 2 Sides

2-DR.50 to 2-DR.59 = Directional: FLOOR Mount

2-DR.59 Freestanding Directional Insert

Series 2: CBP Areas - Identification (Scale: 1/4" = 1'-0")

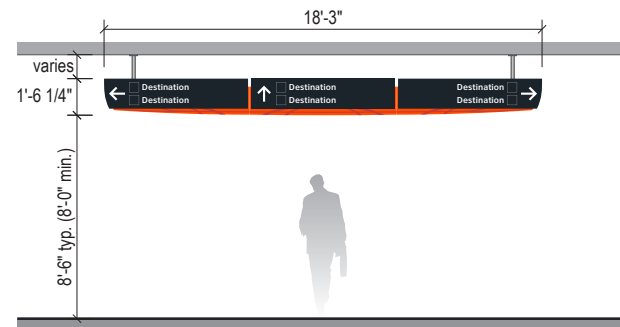
NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs



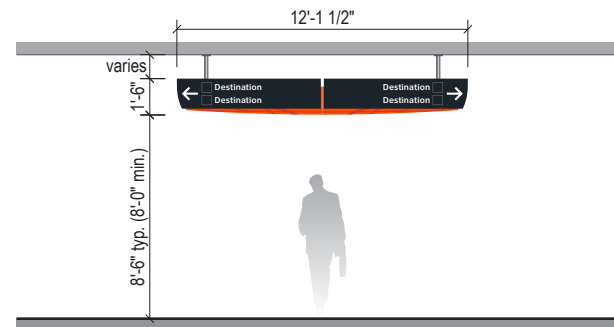
Series 3: Curbside / Ground Transportation - **Pedestrian** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; curbside/G.T. conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

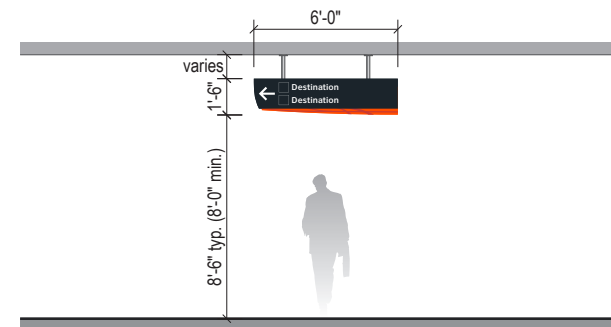
3-DR.10 to 3-DR.19 = Directionals: **CEILING SUSPENDED** Mount



3-DR.11 3-way Ceiling Suspended Directional w/ 3" Text
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

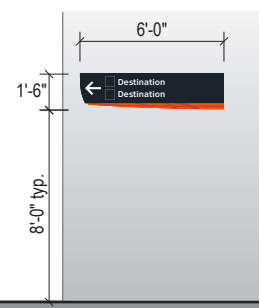


3-DR.12 2-way Ceiling Suspended Directional w/ 3" Text
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

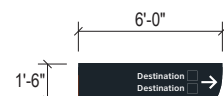


3-DR.13 1-way Ceiling Suspended Directional w/ 3" Text
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

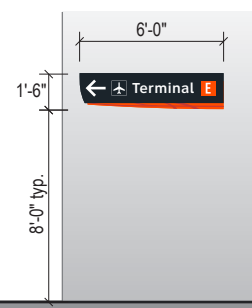
3-DR.20 to 3-DR.29 = Directional: **SOFFIT / WALL** Mount



3-DR.23 1-way Soffit/Wall Mount Directional w/ 3" Text
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 1 Side



3-DR.23-r Right-Facing Variant



3-DR.23b 1-way Soffit/Wall Mount Terminal Trailblazer w/ 5" Text
 - 1 direction / 1 message
 - Arrow = 10"; Symbols = 7.5"
 - 1 Side



3-DR.23b-r Right-Facing Variant

WARNING:

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Series 3: Curbside / Ground Transportation - **Pedestrian** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; curbside/G.T. conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

3-DR.50 to 3-DR.59 = Directional: FLOOR / POST Mount

3-ID.52b Med. 2-way Floor/Post Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

3-ID.53b Med. 1-way Floor/Post Mount Directional w/ 3.5" Text
 - Med. size variant with 3.5" text for increased mounting ht./view dist.
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 5.25"; 2 Sides

3-DR.55 Floor Mount G.T. Directional w/ ID Header
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"; Text = 1.5"
 - ID Header: symbol = 9"; Text = 4"
 - 2 Sides

3-DR.58 Floor Mount Directional w/ 1.5" text
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"
 - 2 Sides

3-ID.20 to 3-ID.29 = Identification: SOFFIT / WALL Mount

NOTE: Use of dynamic display units are being considered at time of this document's publication; static Airline name panels are modular and can be added/subtracted as needed

3-ID.25 Modular Soffit/Wall Mount Curbside Ticketing Entrance ID w/ 3" Airline Names
 - Ticketing/Check-In Text Ht. = 6" cap. ht.
 - Airline Name Text Ht. = 3" cap. ht.
 - Symbols = 1'-2"

3-ID.25b Modular Soffit/Wall Mount Curbside Ticketing Entrance ID w/ 4" Airline Names
 - Ticketing/Check-In Text Ht. = 6" cap. ht.
 - Airline Name Text Ht. = 4" cap. ht.
 - Symbols = 1'-2"

3-ID.25c Modular Soffit/Wall Mount Curbside Ticketing Entrance ID w/ 6" Airline Names
 - Ticketing/Check-In Text Ht. = 6" cap. ht.
 - Airline Name Text Ht. = 6" cap. ht.
 - Symbols = 1'-2"

Series 3: Curbside / Ground Transportation - **Pedestrian** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; curbside/G.T. conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

3-ID.40 to 3-ID.49 = Identification: FLAG Mount

3-ID.41 1-Blade Flag Mount Ground Trans. ID
 - Symbol = 10"; Text = 3"
 - 1 Blade; 2 Sides ea.

3-ID.41b 2-Blade Flag Mount Ground Trans. ID
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

3-ID.50 to 3-ID.59 = Identification: FLOOR / POST Mount

3-ID.52b 2-Blade Floor/Post Mount Ground Trans. ID
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

3-ID.52b 2-Blade Floor/Post Mount Ground Trans. ID
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

3-IN.50 to 3-IN.49 = Informational: FLOOR Mount

3-IN.50 Floor Mount Information Directory - Portrait Config.
 - Directory map artwork area = 36" w x 48" h
 - Header Symbol = 10"; Header Text = 4"
 - 1-2 Sides

Series 3: Curbside / Ground Transportation - **Vehicular** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; curbside/G.T. conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

3-DR.30 to 3-DR.39 = Directional: SOFFIT / BEAM Mount

3-DR.31 Vehicular Soffit/Beam Mount Directional
1 Lane Panel
- Arrow = 12"
- Text = 9"
- Symbol = 14"

3-DR.35 Vehicular Soffit/Beam Mount Directional
2 Lane Panel
- Arrow = 12"
- Text = 9"

3-DR.60 to 3-DR.69 = Directional: COLUMN / POST Mount

3-DR.65 Vehicular Column Mount Directional w/
ID Header & Split Panel Config.
- Arrow = 12"; Text = 5"; Symbol = 8"
- Header Symbol = 12"

3-ID.10 to 3-ID.19 = Identification: CEILING SUSPENDED Mount

3-ID.11 Modular Vehicular Ceiling Suspended Ticketing/Airline Curb ID
- Ticketing ID Text = 6"; Airline Names = 6"-8"
- Symbol = 14"

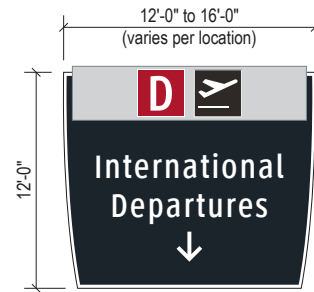
3-ID.30 to 3-ID.39 = Identification: SOFFIT / BEAM Mount

3-ID.31 Modular Vehicular Soffit/Beam Mount Ticketing/Airline Curb ID
- Ticketing ID Text = 6"; Airline Names = 6"-8"
- Symbol = 14"

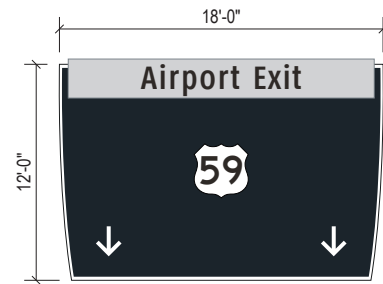
Series 4: Roadway Directionals - **Overhead** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs. Graphics shown may vary from sign type and location.

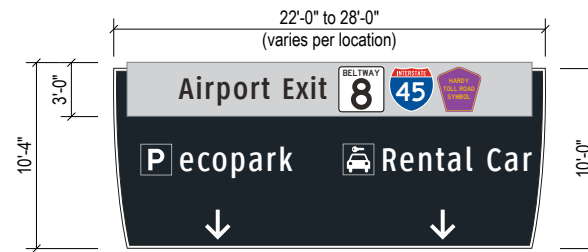
4-DR.10 to 4-DR.19 = OVERHEAD Directional Panels: With Header Panels



- 4-DR.11** 1 Lane Panel
- 1 Arrow (20" ht.)
 - 1-2 Message Lines:
 - 15" primary text
 - 11" secondary text
 - 21" symbol (if used)
 - ID Header (32" symbol)



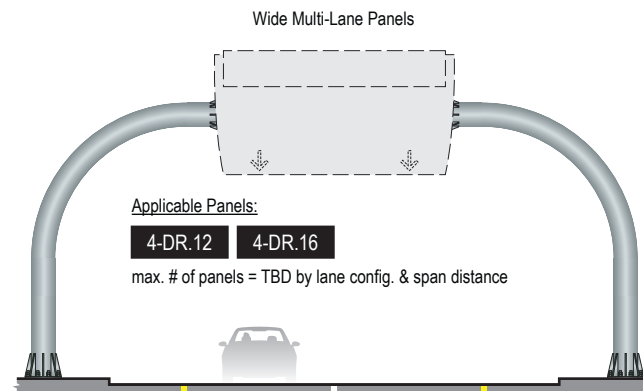
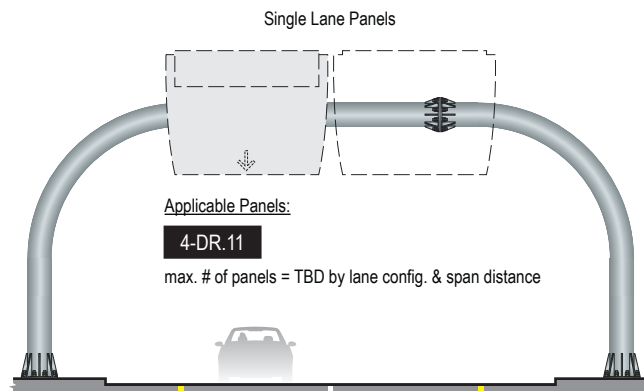
- 4-DR.12** 2 Lane Panel
- 2 Arrows (20" ht.)
 - 1-2 Message Lines:
 - 15" primary text
 - 11" secondary text
 - 21" symbol (if used)
 - ID Header (32" symbol)



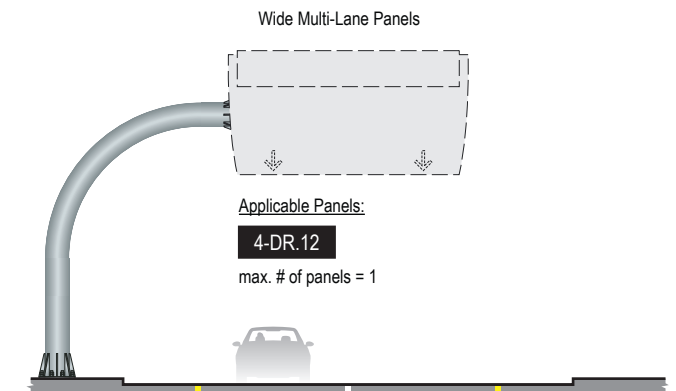
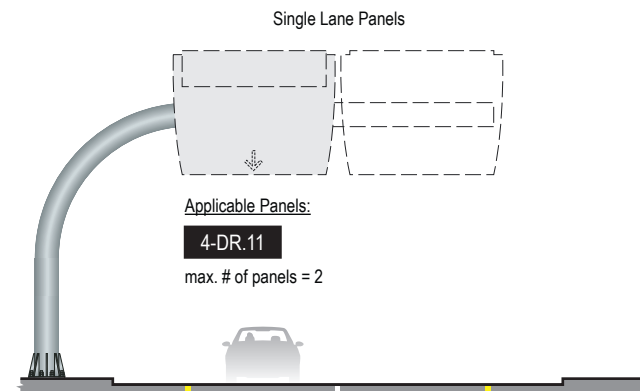
- 4-DR.16** Wider Message Multi-Lane Panel
- 1 or 2 Arrows
 - 1-3 Message Lines:
 - 15" primary text
 - 11" secondary text
 - 21" symbol (if used)
 - ID Header (32" symbol)

Mounting Options (SCALE: 1/16" = 1'-0")

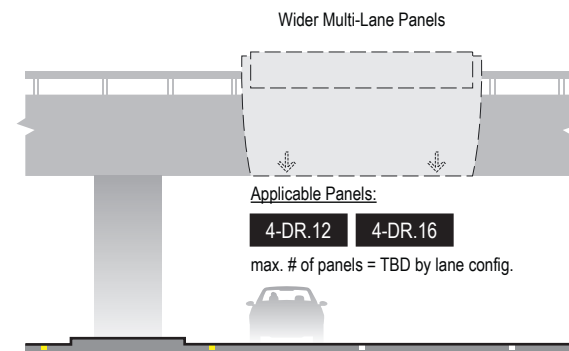
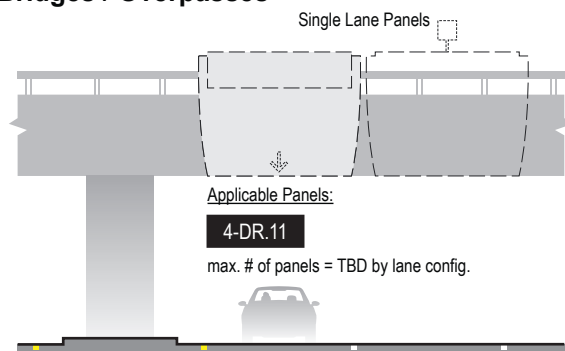
Span Monotube (Freestanding)



Cantilever Monotube (Freestanding)



Bridges / Overpasses



Series 4: Roadway Directionals - **Roadside** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs. Graphics shown may vary from sign type and location.

4-DR.20 to 4-DR.29 = ROADSIDE Directionals: No Header Panels

4-DR.21 Large Roadside Directional
 - 1 Arrow
 - 2-3 Message Lines

4-DR.22 Small Roadside Directional
 - 1 Arrow
 - 1-3 Message Lines

4-DR.23 Small Roadside Directional
 - 1 Arrow
 - 1-3 Message Lines

4-DR.24 Small Roadside Directional
 - 1 Arrow
 - 1-3 Message Lines

4-DR.25 Roadside Cell Phone Lot Trailblazer
 - 1 Arrow
 - 1 Symbol (branded)
 - 1 Message (branded)

4-DR.26 Small Roadside Secondary Directional
 - 1 Arrow (16" ht.)
 - Messages/graphics vary per loc. (6"-8" cap. ht.)
 - Single post

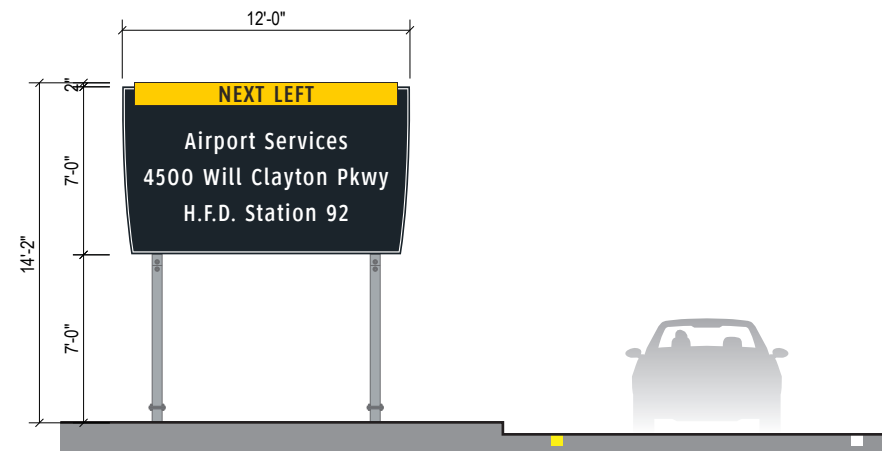
4-DR.27 Small Roadside Secondary Directional w/ Clearance Panel
 - 1 Arrow (16" ht.)
 - Messages/graphics vary per loc. (6"-8" cap. ht.)
 - Supplemental warning panel
 - Single post

4-DR.28 Roadside Trailblazer Directional
 - 1 Arrow
 - 1-3 Messages

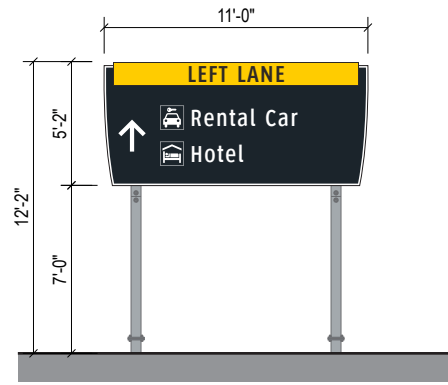
Series 4: Roadway Directionals - **Roadside** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs. Graphics shown may vary from sign type and location.

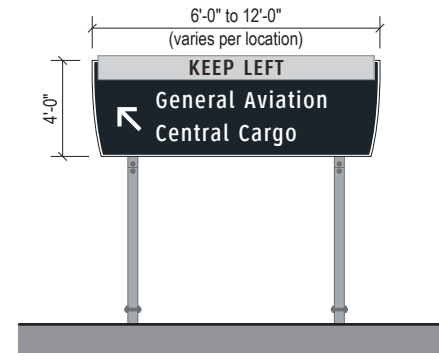
4-DR.30 to 4-DR.39 = ROADSIDE Directionals: With Header Panels



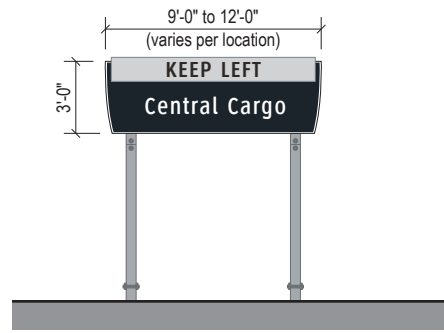
4-DR.32 Large Roadside Directional w/ Header
 - No Arrow
 - 2-3 Message Lines
 - Lane Queuing Header



4-DR.33 Small Roadside Directional w/ Header
 - 1 Arrow
 - 1-2 Message Lines
 - Lane Queuing Header



4-DR.34 Small Roadside Directional w/ Header
 - 1 Arrow
 - 1-2 Message Lines
 - Lane Queuing Header



4-DR.35 Small Roadside Directional w/ Header
 - 1 Arrow
 - 1-2 Message Lines
 - Lane Queuing Header

THIS SPACE LEFT INTENTIONALLY BLANK

Series 4: Roadway Identification/Informational - **Roadside** (Scale: 3/32" = 1'-0") NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs. Graphics shown may vary from sign type and location.

4-ID.01 to 4-ID.09 = ROADSIDE Identification

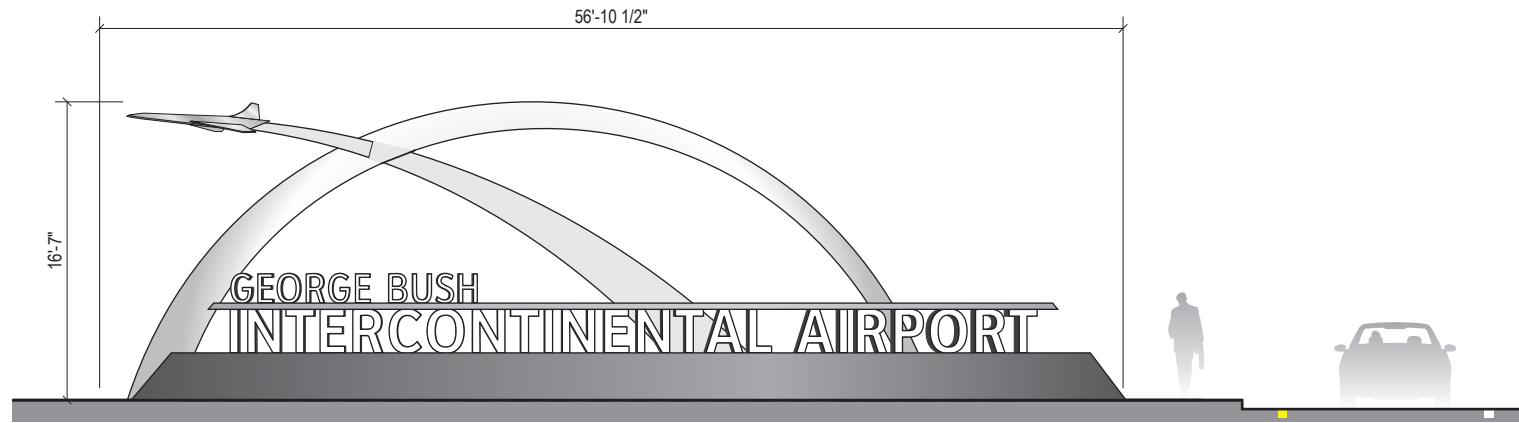
4-ID.01 Roadside Identification - Airline/Terminal
 - Terminal ID Header
 - Up to 8 Airline Names

4-IN.01 to 4-IN.09 = ROADSIDE Informational

4-IN.01 Roadside Informational - Parking
 - Terminal/Parking ID Header
 - Dynamic Status Area

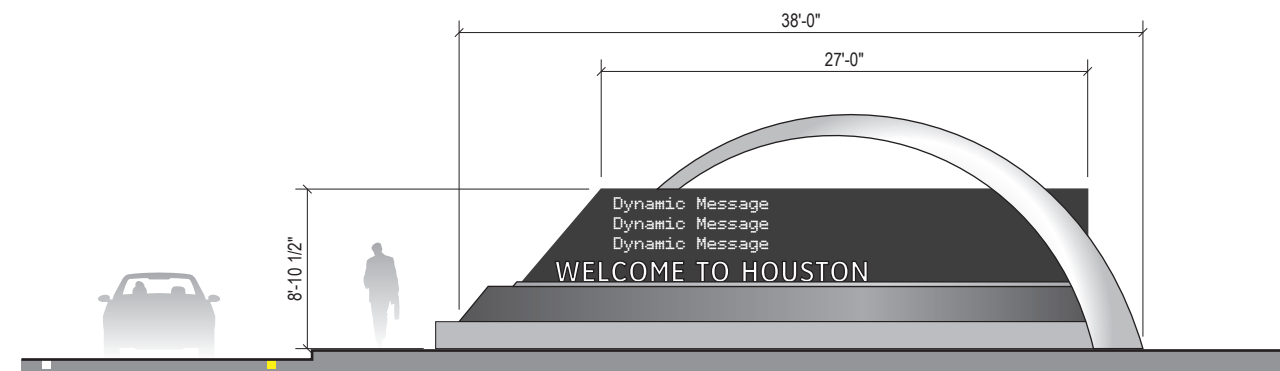
Series 4: Roadway Identification/Informational - **Roadside** (Scale: 3/32" = 1'-0") NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs. Graphics shown may vary from sign type and location.

4-ID.10 to 4-ID.19 = **ROADSIDE** Identification - Airport Gateways



4-ID.11 Roadside Identification - Airport Gateway Monument
 - Airport ID letters = int. illum. channel letters
 - All other structural elements = up-lit

4-IN.11 to 4-IN.19 = **ROADSIDE** Informational - Welcome Monument



4-IN.11 Roadside Informational - Welcome to Houston Monument
 - "Welcome" ID letters = int. illum. channel letters
 - Dynamic backdrop display with up to 3 lines of message text

Series 5: Parking - Vehicular (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; garage conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

5-DR.01 to 5-DR.10 = Directionals: CEILING Mount - Suspended

5-DR.01 Ceiling Suspended Directional;
- 2 directions; 2 messages per direction

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

NOTE: Suspension structure on all suspended sign types to include hinge feature that allows entire sign to pivot forward/backward in order to limit damage (in case of accidental vehicular collision)

5-DR.02 Ceiling Suspended Directional;
- 1 direction; 2 messages

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.03 Ceiling Suspended Directional;
- 1 direction; 1 message

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.05 Ceiling Suspended Directional; Dual Lanes w/ High-Contrast Header;
- 1 direction 2 messages per panel

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.06 Ceiling Suspended Directional w/ High-Contrast Header;
- 1 direction; 1 message

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.10 Ceiling Suspended Level ID Directional/Space-Count Informational
- Re-Skin (L1 @ AB Garage only)

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

NOTE: This sign is designed as a retro-fit over an existing space counting system at the AB Parking Garage at the time of this document's publication; new technologies are being explored by HAS and may eventually render this sign inaccurate and not needed

Level	Empty Spaces
8	446
6	304
4	171
2	50

5-DR.11 to 5-DR.20 = Directionals: WALL / BEAM / SOFFIT Mount

5-DR.11 Wall/Beam/Soffit Mount Directional;
- 2 directions; 2 messages per direction

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.12 Wall/Beam/Soffit Mount Directional;
- 1 direction; 2 messages

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.15 Wall/Beam/Soffit Directional w/ High-Contrast Header;
- 1 direction; 2 messages

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.12b Wall/Beam/Soffit Mount Directional;
- Right-facing panel; 1 direction; 2 messages

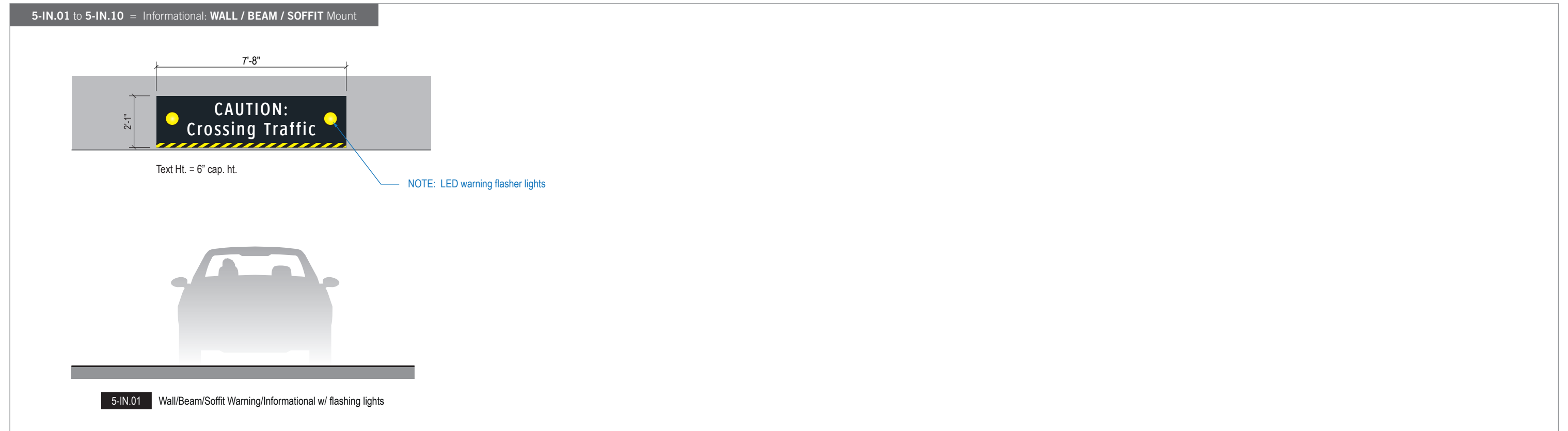
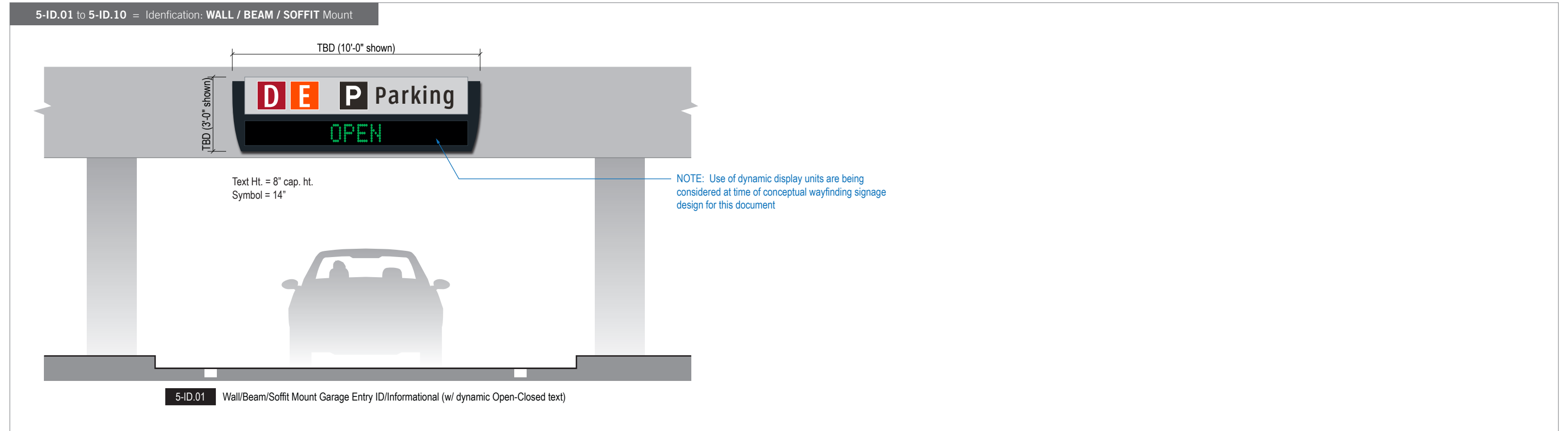
Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

5-DR.15b Wall/Beam/Soffit Directional w/ High-Contrast Header;
- Right-facing panel; 1 direction; 2 messages

Text Ht. = 5" cap. ht.
Symbol = 7"
Arrow = 10"

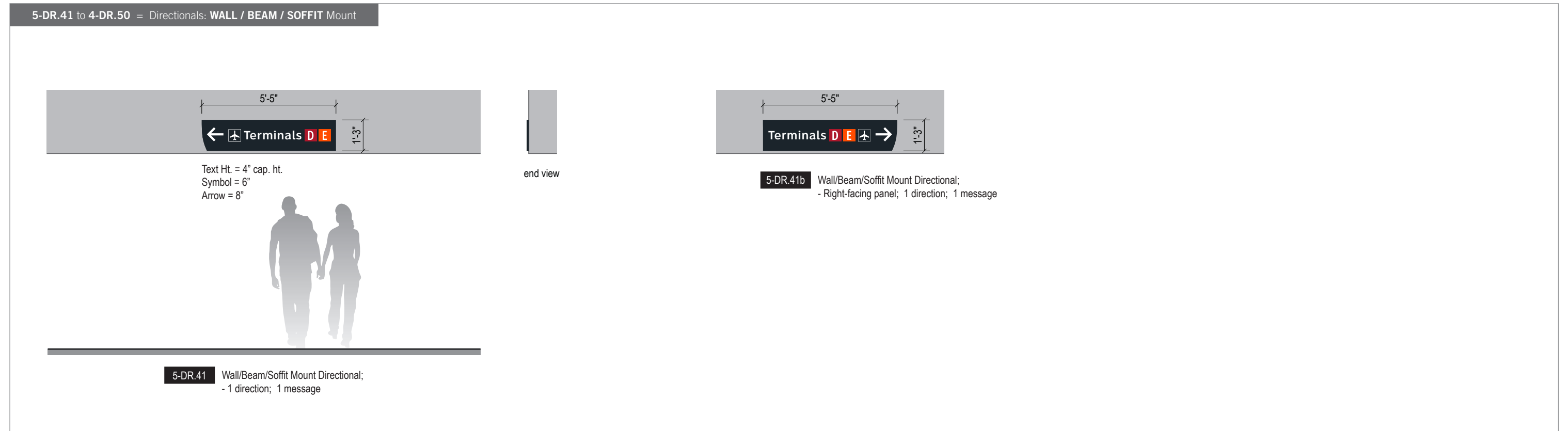
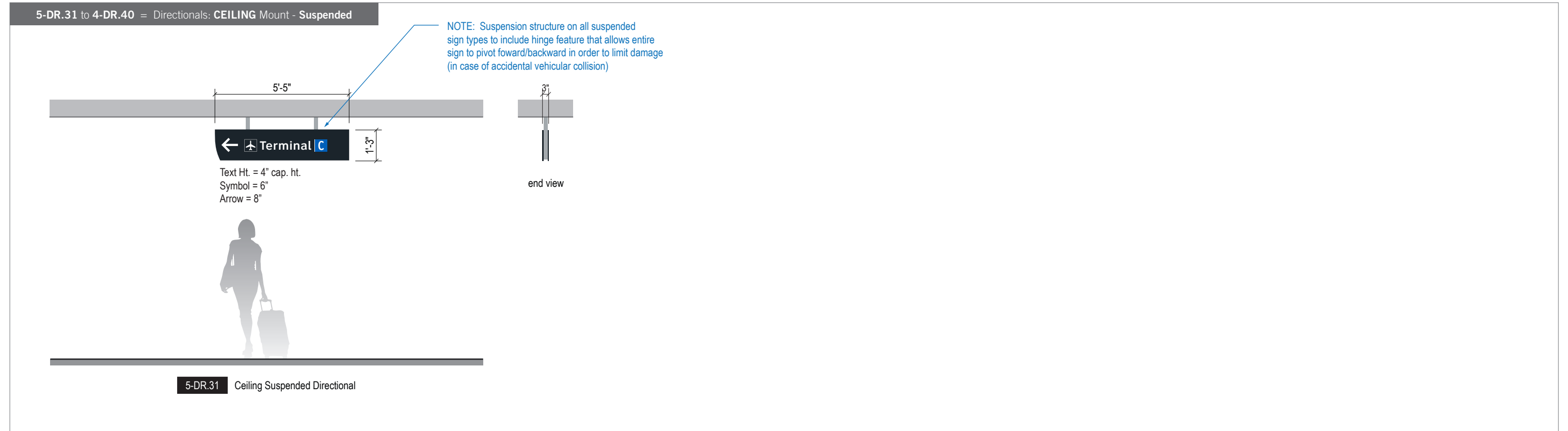
Series 5: Parking - Vehicular (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; garage conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs



Series 5: Parking - Pedestrian (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; garage conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs



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Series 5: Parking - Pedestrian (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; garage conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

5-ID.51 to 5-ID.60 = Identification: COLUMN WRAP

NOTE:
 - Square/Rectangular Columns = terminal letter & section no. on all four sides;
 - Round Columns = terminal letter & section no. only on two directly opposing sides parallel to parking rows

Garage AB version (Term. A end only):
 Garage AB version (Term. B end only):
 Garage C: West version:
 Garage C: East version:
 Garage DE version:

5-ID.51 Column Wrap Parking Section/Terminal ID

NOTE: Elevator core areas are unique per garage and/or level; final size of super-graphics to be determined during final design per field verified conditions; background and watermark colors are to be applied per the applicable corresponding terminal that the elevator core services

5-ID.52 Wall Mount Super-Graphics - Elevator/Stair Core ID with Level No.

5-ID.61 to 5-ID.70 = Identification: WALL / BEAM / SOFFIT Mount

5-ID.61 Wall/Soffit/Beam Mount Elevator ID
 Header Text Ht. = 3" cap. ht.
 Header Symbol = 4"
 Terminal Text Ht. = 4 1/2" cap. ht.
 Terminal Symbol = 6"

5-ID.65 Wall/Soffit/Beam Mount Elevator Level ID;
 - w/ Floor Directory & Fire Safety Warning Area



HAS WAYFINDING SYSTEM

Signage Design Guidelines, Standards and Typical Applications

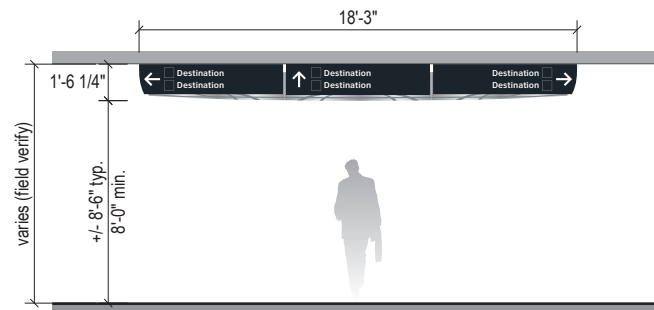
VOLUME 3.0

3.1 Wayfinding Sign Families - HOU

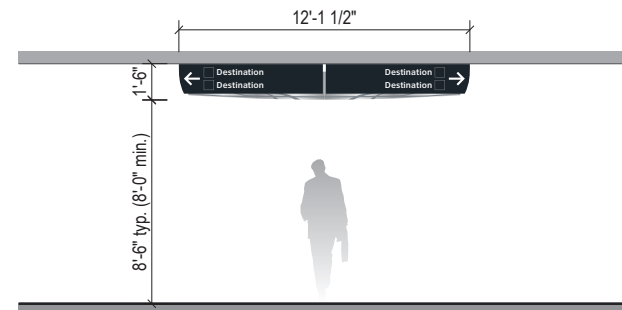
Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

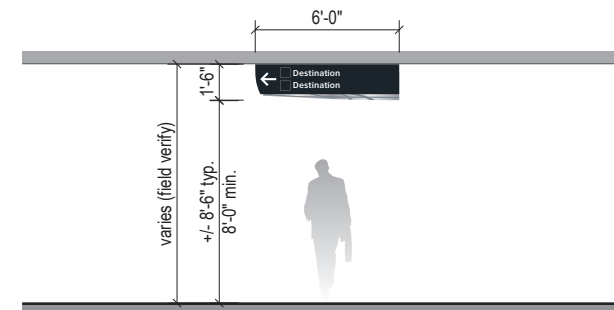
1-DR.00 to 1-DR.09 = Directionals: CEILING FLUSH Mount (Top Flush)



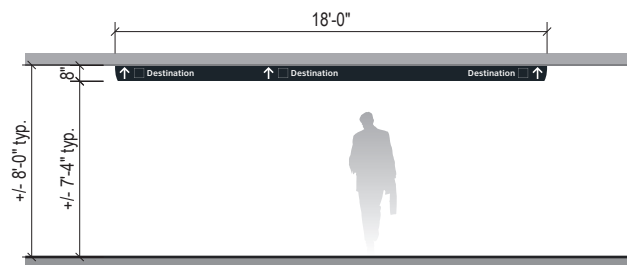
1-DR.01 3-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



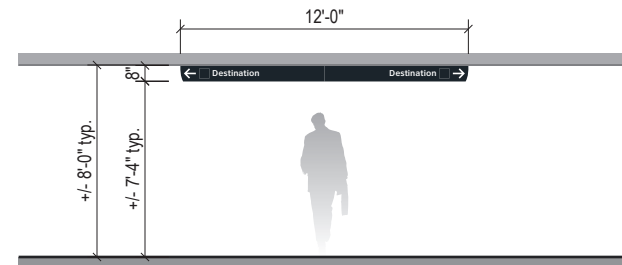
1-DR.02 2-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



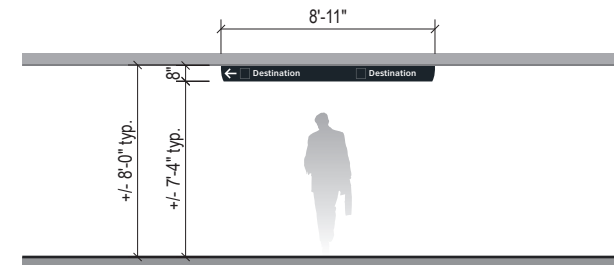
1-DR.03 1-way Ceiling Flush Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



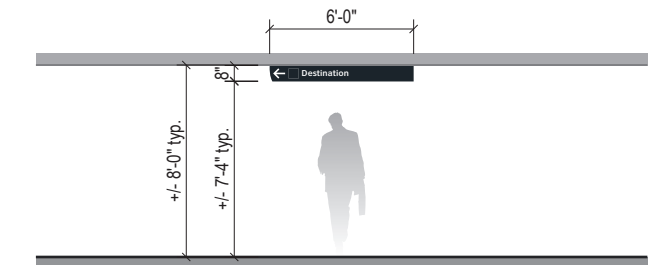
1-DR.06 3-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 3 directions / 1 message per direction
 - Arrow = 6"; Symbols = 5"
 - 2 Sides



1-DR.07 2-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 3 directions / 1 message per direction
 - Arrow = 6"; Symbols = 5"
 - 2 Sides



1-DR.07b Limited Width 2 Message Variant Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - Limited width mounting condition variant
 - 1 direction / 1-2 messages
 - Arrow = 6"; Symbols = 5"
 - 2 Sides

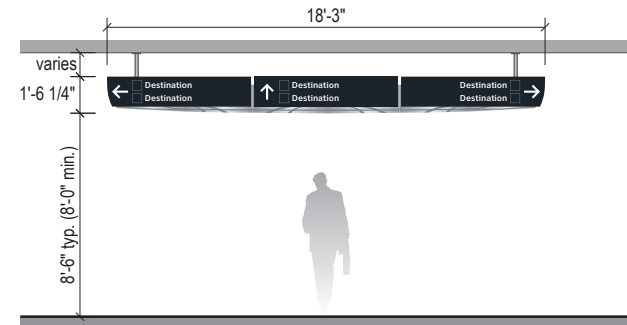


1-DR.08 1-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 1 direction / 1 message
 - Arrow = 6"; Symbols = 5"
 - 2 Sides

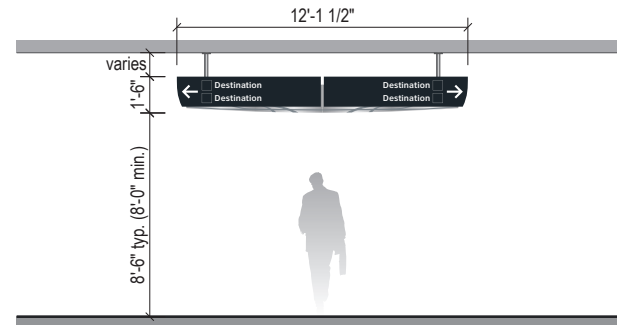
Series 1: Terminal / Concourse - **Directionals** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

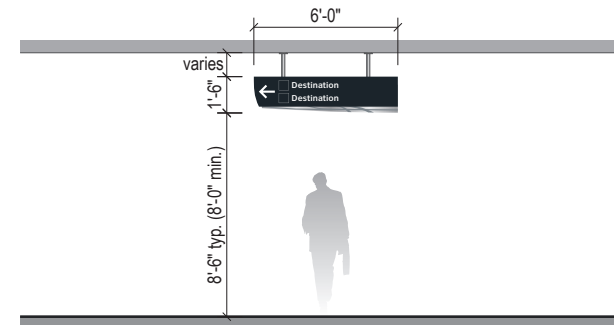
1-DR.10 to 1-DR.19 = Directionals: **CEILING SUSPENDED** Mount



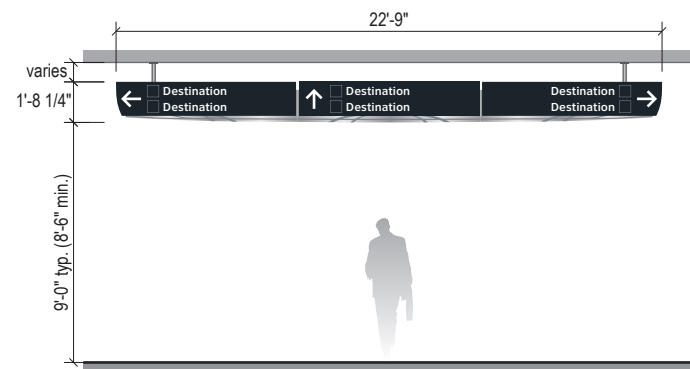
1-DR.11 3-way Ceiling Suspended Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



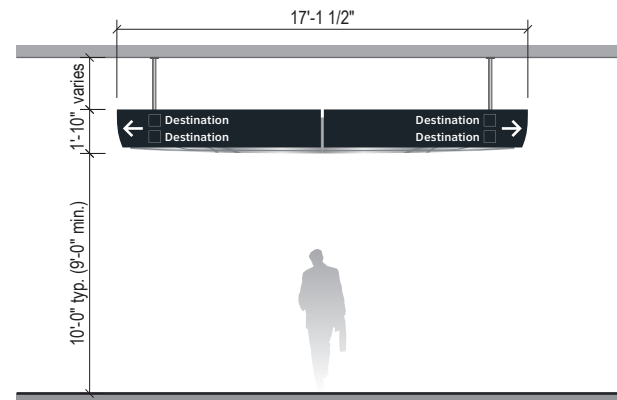
1-DR.12 2-way Ceiling Suspended Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



1-DR.13 1-way Ceiling Suspended Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides



1-DR.11b Med. 3-way Ceiling Suspended Directional w/ 4" Text
 - Medium size variant with 4" text for increased mounting ht. and viewing distances
 - 3 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 6"
 - 2 Sides



1-DR.12c Large 2-way Ceiling Suspended Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht. and viewing distances
 - 2 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 6"
 - 2 Sides

Series 1: Terminal / Concourse - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.20 to 1-DR.29 = Directional: SOFFIT / WALL Mount

1-DR.21b Med. 3-way Soffit/Wall Mount Directional w/ 3.5" Text
 - Medium size variant with 3.5" text for increased mounting ht. and viewing distances
 - 3 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"
 - 1 Side

1-DR.22 2-way Soffit/Wall Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 1 Side

1-DR.22c Large 2-way Soffit/Wall Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht. and viewing distances
 - 3 directions / 1-2 messages per direction
 - Arrow = 10"; Symbols = 5.25"
 - 1 Side

1-DR.23 1-way Soffit/Wall Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 directions / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 1 Side

1-DR.30 to 1-DR.39 = Directional: WALL Mount - Plaques

1-DR.32 Wall Mount Plaque Directional w/ 1.5" text
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"
 - 1 Side

1-DR.40 to 1-DR.49 = Directional: FLAG Mount

1-DR.42 1-way Flag Mount Directional w/ 3" Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

1-DR.42c Large 1-way Flag Mount Directional w/ 4" Text
 - Large size variant with 4" text for increased mounting ht. and viewing distances
 - 1 direction / 1-2 messages
 - Arrow = 10"; Symbols = 6"
 - 2 Sides

1-DR.50 to 1-DR.59 = Directional: FLOOR Mount

1-DR.58 Floor Mount Directional w/ 1.5" text
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"
 - 2 Sides

Series 1: Terminal / Concourse - Identification (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-ID.00 to 1-ID.09 = Identification: CEILING FLUSH Mount (Top Flush)

1-ID.05 Ceiling Flush Mount Baggage Claim Carousel ID
 - Symbol = 1'-1"; Text = 1'-1"
 - 2 Sides

1-ID.07b Low Clearance Ceiling Flush Mount Entry ID
 - Symbol = 6"; Text = 4"
 - 2 Sides

1-ID.20 to 1-ID.29 = Identification: SOFFIT / WALL Mount

1-ID.21 Soffit/Wall Mount Gate Door ID
 - Text = 9"
 - 1 Side

1-ID.21b Backdrop Wall Mount Gate Service Desk ID
 - Text = 7.5"
 - 1 Side

1-ID.29 Wall Mount Level ID @ Elevators
 - 1 Side

1-ID.30 to 1-DR.39 = Identification: WALL Mount - Plaques

1-ID.31 Wall Mount ADA Tactile Restroom ID
 - All mounting, text/graphic sizing & tactile elements per ADA/TAS
 - 1 Side

1-RF.00 to 1-RF.09 = Identification/Informational: RE-FACE / RETROFIT

1-RF.01 Re-Face/Retrofit: Large Flag Mount ID
 - Re-face/Retrofit of existing large Flag IDs (verify size in field)
 - Re-paint exist. box HAS Charcoal Gray
 - Curved accent pieces added in field
 - Symbol = +/- 1'-4" shown
 - 2 Sides

1-RF.02 Re-Face/Retrofit: Ceiling Mount Flag ID
 - Re-face/Retrofit of existing smaller Flag IDs (verify size in field)
 - Re-paint exist. box HAS Charcoal Gray
 - Curved accent pieces added in field
 - Symbol = +/- 12" shown
 - 2 Sides

1-RF.03 Re-Face/Retrofit: Large Flag Mount Gate ID
 - Re-face/Retrofit of existing large Flag IDs (verify size in field)
 - Re-paint exist. box HAS Charcoal Gray
 - Curved accent pieces added in field
 - Text = +/- 12" shown
 - 2 Sides

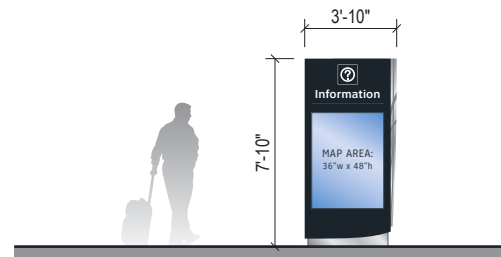
1-RF.04 Re-Face/Retrofit: Moving Walkway Gen. Info
 - New faces applied to existing susp. box
 - Re-paint exist. box HAS Charcoal Gray
 - Symbols = 5"; Text = 3" and 2"
 - 2 Sides

1-RF.04b Re-Face/Retrofit: Moving Walkway Caution Info
 - New faces applied to exist. susp. box
 - Re-paint exist. box HAS Charcoal Gray
 - Text = 4" and 3"
 - 2 Sides

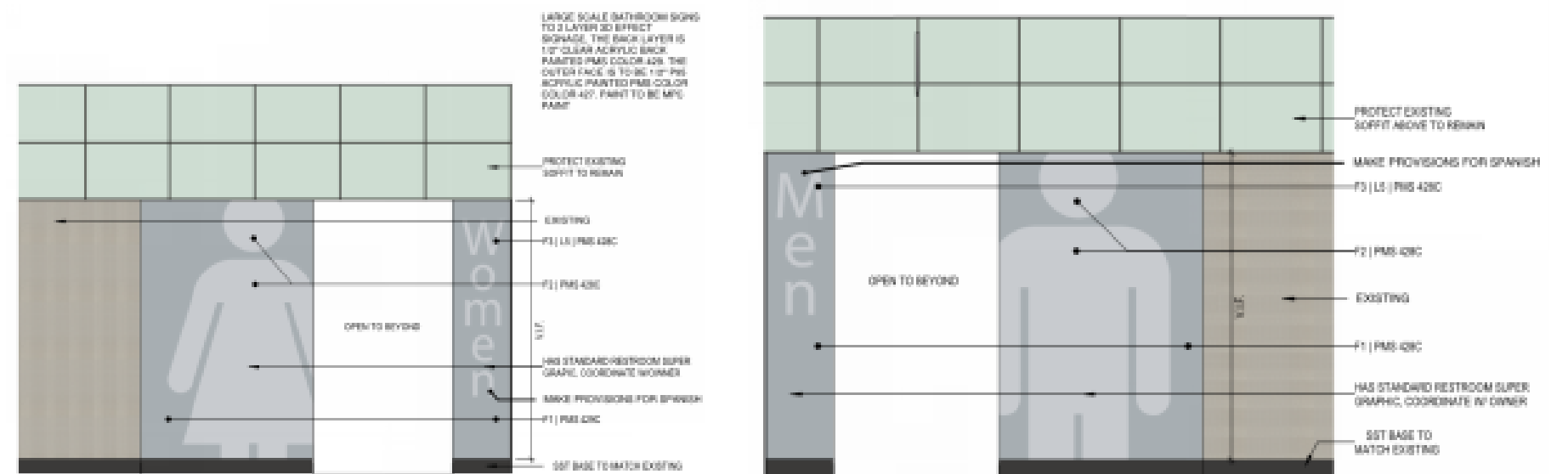
Series 1: Terminal / Concourse - **Informational** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-IN.50 to 1-IN.59 = Informational: FLOOR Mount



- 1-IN.50 Floor Mount Information Directory - Portrait Config.
- Directory map artwork area = 36"w x 48"h
(Note: Directory map artwork by others)
- Header Symbol = 10"; Header Text = 4"
- 1-2 Sides

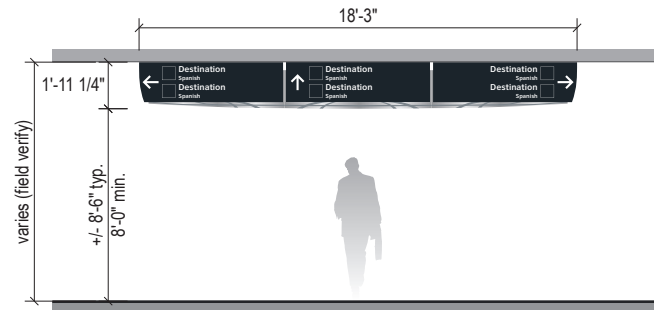


Typical Restroom Graphics

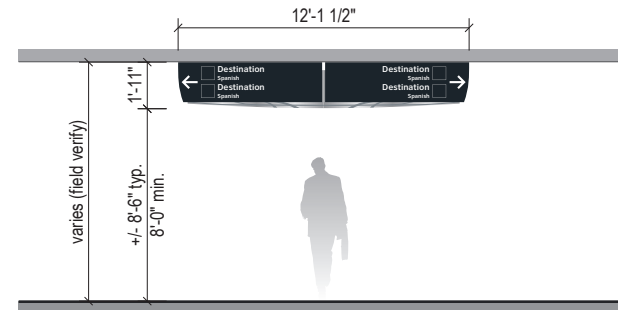
Signs with Supplemental Spanish (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

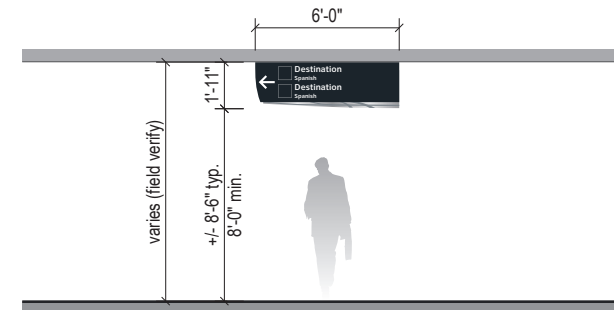
1-DR.00 to 1-DR.09 = Directionals: CEILING FLUSH Mount (Top Flush)



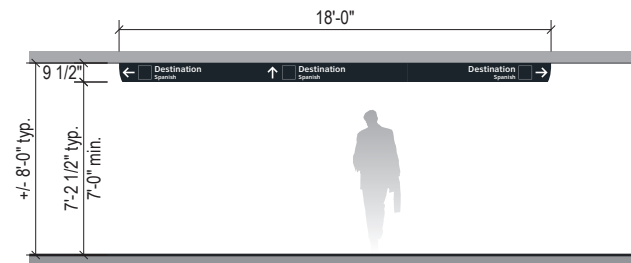
1-DR.01-S 3-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



1-DR.02-S 2-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 2 direction / 1-2 messages
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



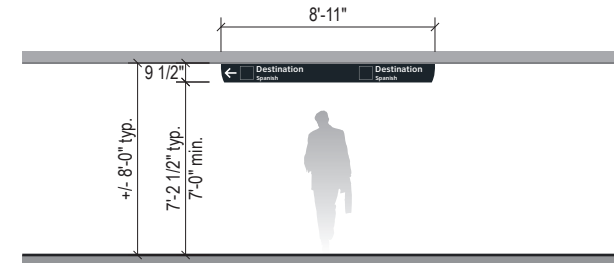
1-DR.03-S 1-way Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 6.75"
 - 2 Sides



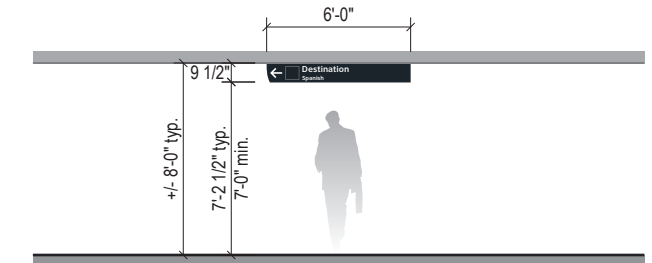
1-DR.06-S 3-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 3 directions / 1 message per direction
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides



1-DR.07-S 2-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 2 directions / 1 message per direction
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides



1-DR.07b-S Limited Width 2 Message Variant Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - Limited width mounting condition variant
 - 1 direction / 1-2 messages
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides

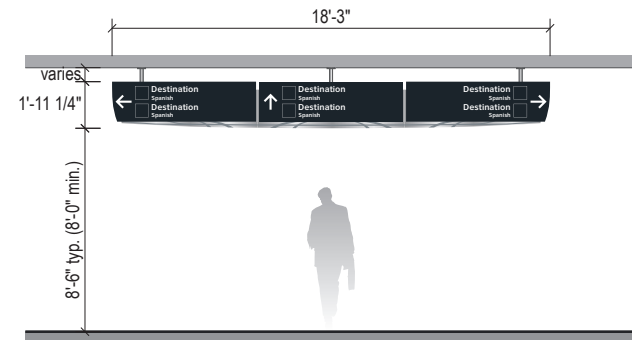


1-DR.08-S 1-way Low Clearance Ceiling Flush Mount Directional w/ 3" Text and 2" Supplemental Spanish Text
 - For use in low clearance (i.e. 8'-0" A.F.F.) ceiling areas
 - 1 direction / 1 message
 - Arrow = 6"; Symbols = 6.75"
 - 2 Sides

Signs with Supplemental Spanish (Scale: 1/8" = 1'-0")

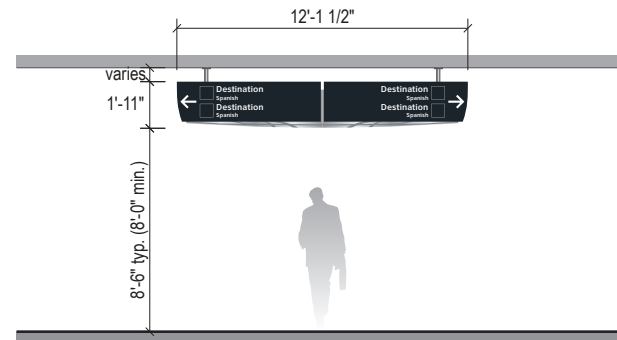
NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.10 to 1-DR.19 = Directionals: CEILING SUSPENDED Mount



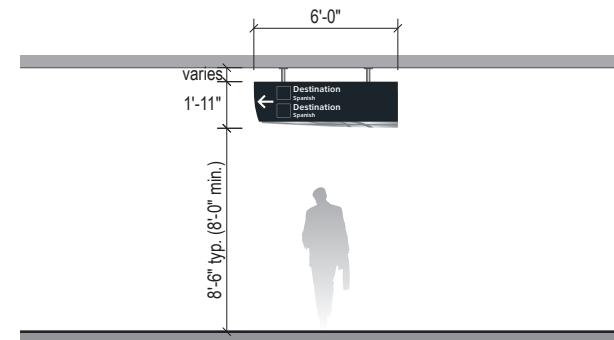
- 1-DR.11-S** 3-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
- 3-DR.11-S**
 - Standard minimum size overhead directional
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

Sign Code for locations within Curbside/Ground Transportation areas



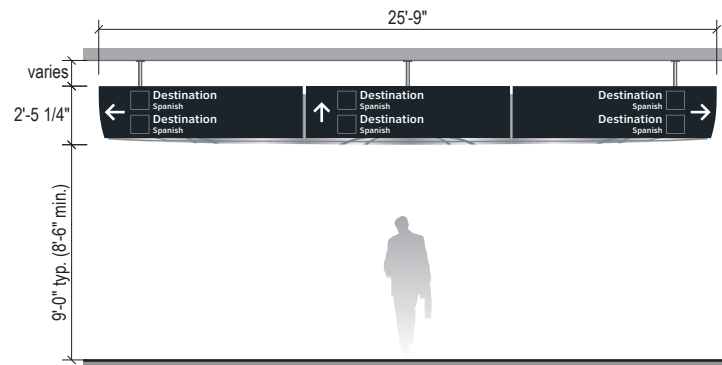
- 1-DR.12-S** 2-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
- 3-DR.12-S**
 - Standard minimum size overhead directional
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

Sign Code for locations within Curbside/Ground Transportation areas

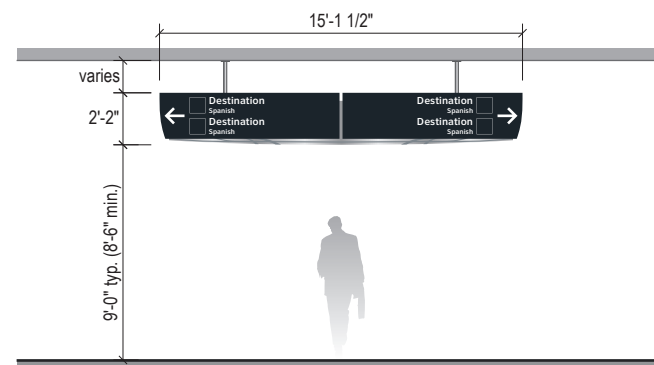


- 1-DR.13-S** 1-way Ceiling Suspended Directional w/ 3" Text and 2" Supplemental Spanish Text
- 3-DR.13-S**
 - Standard minimum size overhead directional
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

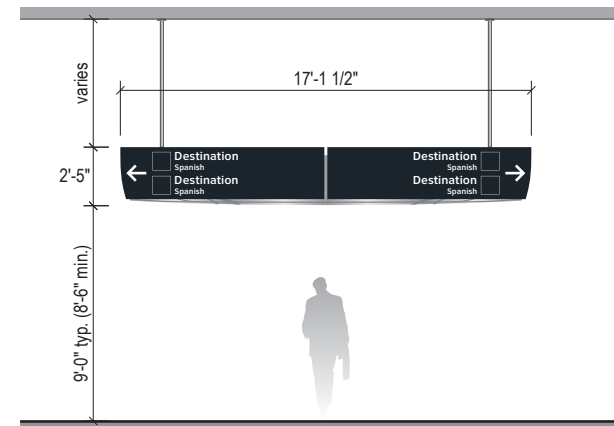
Sign Code for locations within Curbside/Ground Transportation areas



- 1-DR.11c-S** Large 3-way Ceiling Suspended Directional w/ 4" Text and 2.75" Supplemental Spanish Text
- Large size variant with 4" text for increased mounting ht. and viewing distances
- 3 directions / 1-2 messages per direction
- Arrow = 10"; Symbols = 9.25"
- 2 Sides



- 1-DR.12b-S** Med. 2-way Ceiling Suspended Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text
- Medium size variant with 3.5" text for increased mounting ht. and viewing distances
- 2 directions / 1-2 messages per direction
- Arrow = 10"; Symbols = 8"
- 1 Side



- 1-DR.12c-S** Large 2-way Ceiling Suspended Directional w/ 4" Text and 2.75" Supplemental Spanish Text
- Large size variant with 4" text for increased mounting ht. and viewing distances
- 2 directions / 1-2 messages per direction
- Arrow = 10"; Symbols = 9.25"
- 2 Sides

Signs with Supplemental Spanish (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

1-DR.20 to 1-DR.29 = Directional: SOFFIT / WALL Mount

1-DR.21b-S MEDIUM 3-way Soffit/Wall Mount Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text

- Medium size variant with 3.5" text for increased mounting ht. and viewing distances
- 3 directions / 1-2 messages per direction
- Arrow = 10"; Symbols = 8"
- 1 Side

1-DR.22-S 2-way Soffit/Wall Mount Directional w/ 3" Text and 2" Supplemental Spanish Text

- Standard minimum size overhead directional
- 2 directions / 1-2 messages per direction
- Arrow = 8"; Symbols = 6.75"
- 1 Side

1-DR.22b-S Med. 2-way Soffit/Wall Mount Directional w/ 3.5" Text and 2.375" Supplemental Spanish Text

- Medium size variant with 3.5" text for increased mounting ht. and viewing distances
- 3 directions / 1-2 messages per direction
- Arrow = 10"; Symbols = 8"
- 1 Side

1-DR.40 to 1-DR.49 = Directional: FLAG Mount

1-DR.42-S 1-way Flag Mount Directional w/ 3" Text and 2" Supplemental Spanish Text

- Standard minimum size overhead directional
- 1 direction / 1-2 messages
- Arrow = 8"; Symbols = 6.75"
- 2 Sides

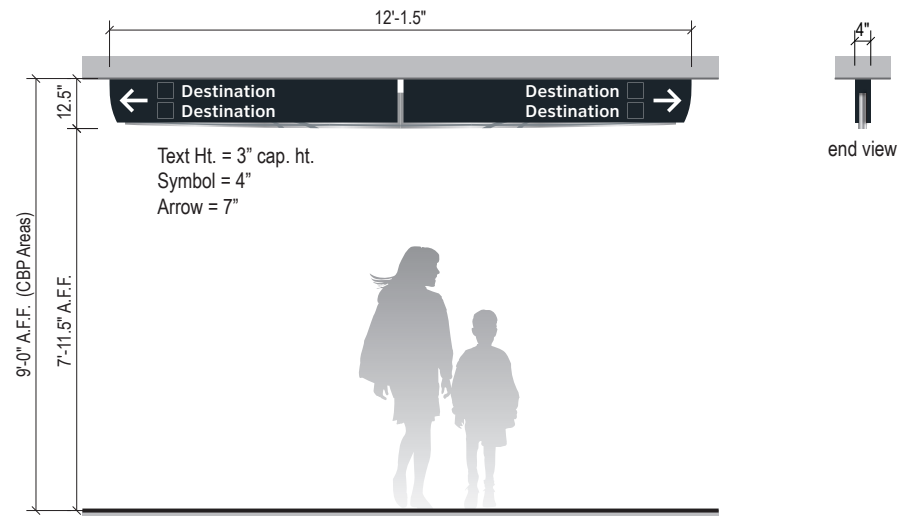
1-DR.42c-S Large 1-way Flag Mount Directional w/ 4" Text and 2.75" Supplemental Spanish Text

- Large size variant with 4" text for increased mounting ht. and viewing distances
- 1 direction / 1-2 messages
- Arrow = 10"; Symbols = 9.25"
- 2 Sides

Series 2: CBP Areas - Directional (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

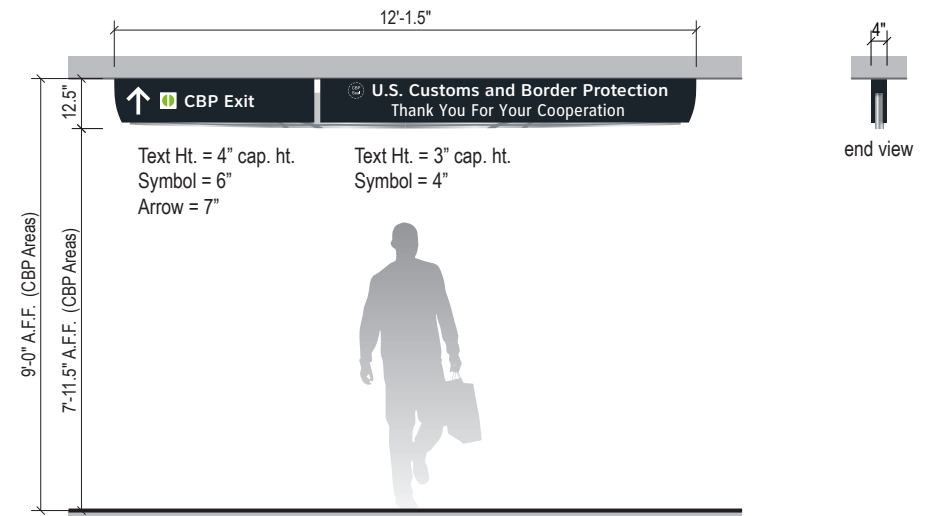
2-DR.01 to 2-DR.09 = Directionals: CEILING Mount (Flush top)



2-DR.01 Ceiling Mount (Flush Top) Directional; low CBP ceiling conditions; 2 directions; 1-2 messages / direction

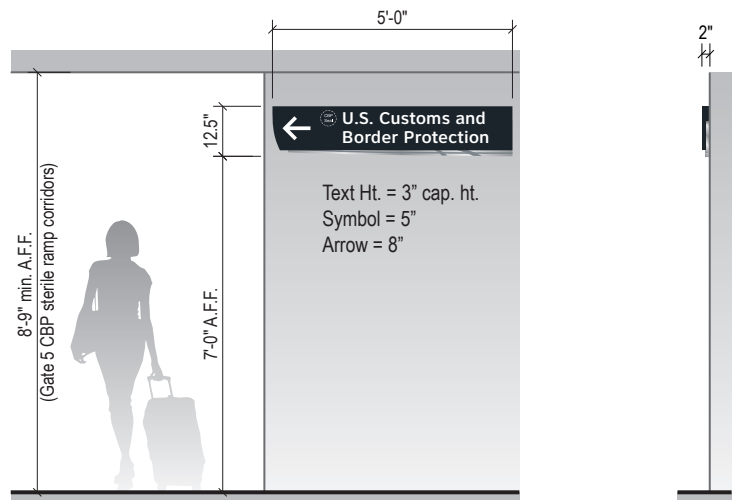


2-DR.02 Ceiling Mount (Flush Top) Directional; low CBP ceiling conditions; 1 direction; 1-2 messages



2-DR.06 Ceiling Mount (Flush Top) Directional; CBP Main Exit / Thank You Notification

2-DR.10 to 2-DR.19 = Directionals: WALL Mount



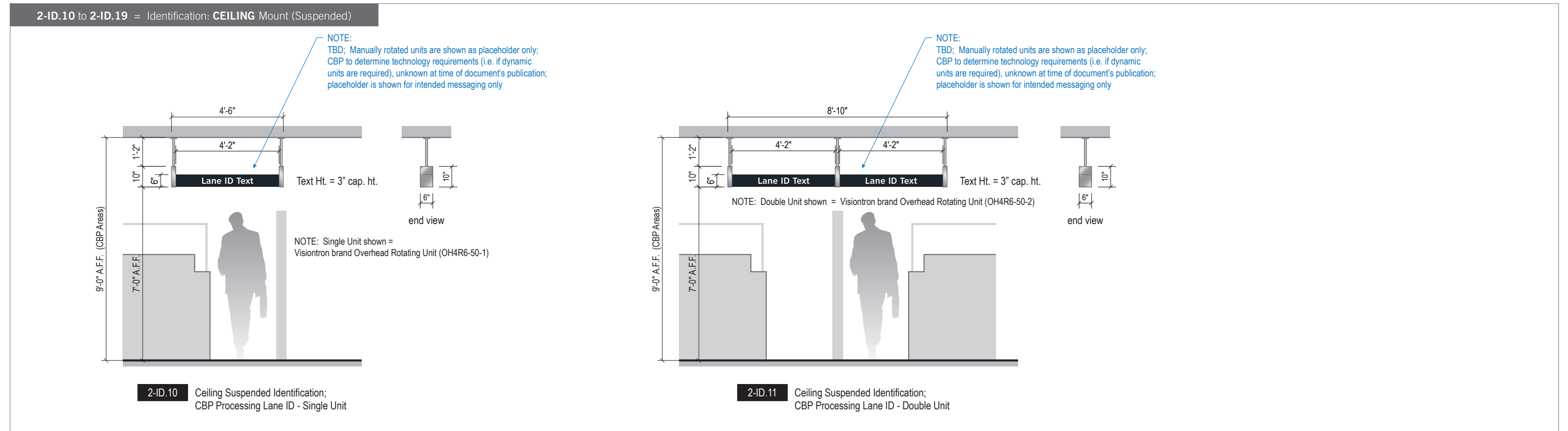
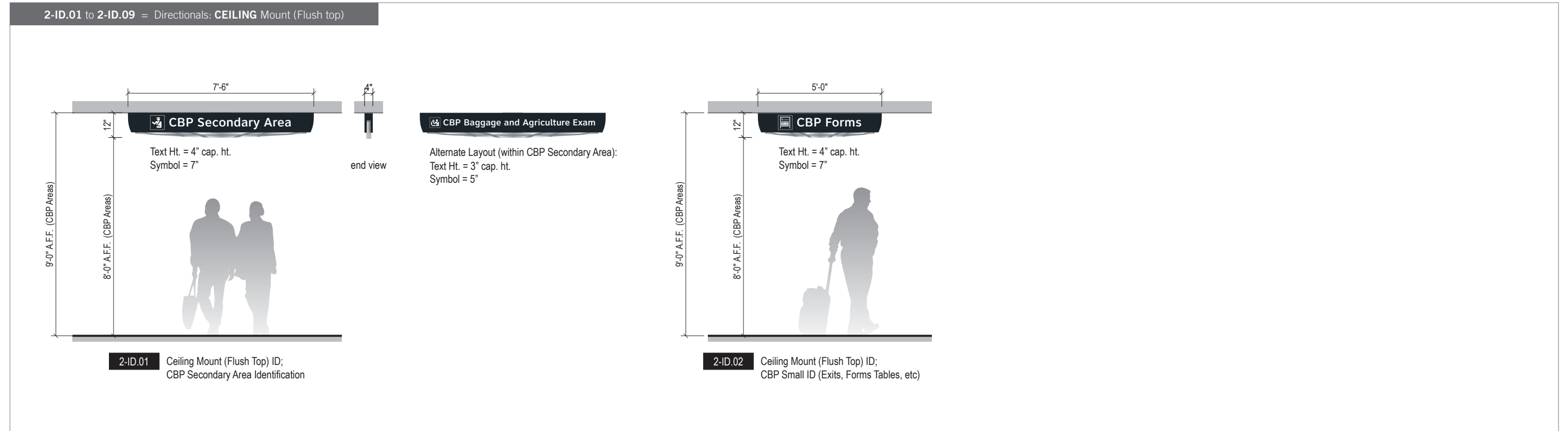
2-DR.10 Wall/Soffit Mount Directional; Left Facing CBP limited-width sterile corridors/areas



2-DR.10b Wall/Soffit Mount Directional; Right Facing; CBP limited-width sterile corridors/areas

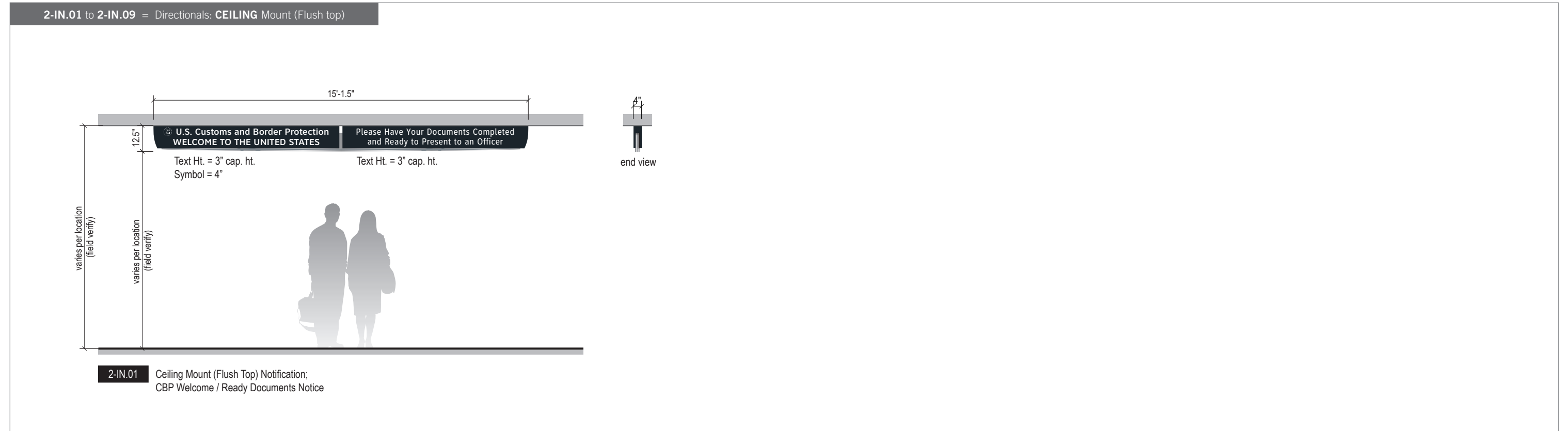
Series 2: CBP Areas - Identification (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs



Series 2: CBP Areas - **Informational** (Scale: 1/4" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs



Series 3: Curbside / Ground Transportation - Directionals (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

3-DR.10 to 3-DR.19 = Directionals: CEILING SUSPENDED Mount

3-DR.11 3-way Ceiling Suspended Directional w/ 3" Text
 - 3 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

3-DR.12 2-way Ceiling Suspended Directional w/ 3" Text
 - 2 directions / 1-2 messages per direction
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

3-DR.13 1-way Ceiling Suspended Directional w/ 3" Text
 - 1 direction / 1-2 messages
 - Arrow = 8"; Symbols = 5"
 - 2 Sides

3-DR.15 3-way Ceiling Suspended Ground Trans. Zone Directional with Traffic Safety Alert Panel
 - ID header panel (symbol = 6"; text = 3.5")
 - 3 directions / 1-3 messages per direction
 - Arrow = 8"; Symbols = 5"
 - Traffic safety alert panel text = 3.5"
 - 2 Sides

3-DR.20 to 3-DR.29 = Directional: SOFFIT / WALL Mount

3-DR.23 1-way Soffit/Wall Mount Terminal Trailblazer w/ 5" Text
 - 1 direction / 1 message
 - Arrow = 10"; Symbols = 7.5"
 - 1 Side

3-DR.23b Right-Facing Variant

3-DR.50 to 3-DR.59 = Directional: FLOOR Mount

3-DR.55 Floor Mount G.T. Directional w/ Zone ID Header
 - 1-3 directions / multiple message variations
 - Arrow = 5"; Symbols = 2.75"; Text = 1.5"
 - ID Header: symbol = 9"; "Zone" text = 4"; No. = 12"
 - 2 Sides

Series 3: Curbside / Ground Transportation - Identification (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; terminal conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

3-ID.20 to 3-ID.29 = Identification: SOFFIT / WALL Mount

3-ID.27 Wall Mount Departures Curb Entrance Airline ID
 - Symbol = 8"; Text = 4"
 - 1 Side

3-ID.40 to 3-ID.49 = Identification: FLAG Mount

3-ID.41 1-Blade Flag Mount Curb/Ground Trans. ID @ Single Columns
 - Symbol = 10"; Text = 3"
 - 1 Blade; 2 Sides ea.

3-ID.41b 2-Blade Flag Mount Curb/Ground Trans. ID @ Single Columns
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

3-ID.41c 2-Blade Flag Mount Curb/Ground Trans. ID @ Double Columns
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

3-ID.46 Large Flag Mount Departures Curb Airline ID
 - Symbol = 10"; Text = 3"
 - 2 Sides

3-ID.50 to 3-ID.59 = Identification: FLOOR / POST Mount

3-ID.52b 2-Blade Floor/Post Mount Ground Trans. ID
 - Symbol = 10"; Text = 3"
 - 2 Blades; 2 Sides ea.

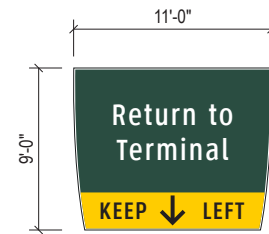
This document is intended to provide design intent, and should only be used as a general guideline. No information contained herein should be construed as an engineering document. The manufacturer or installer shall be responsible for all engineering and specifications with regard to structural, electrical, mechanical, foundation and installation.

WARNING:
 This record contains sensitive security information that is controlled under 49 CFR parts 15 and 1502. No part of this record may be disclosed to persons with a "need to know," as defined in 49 CFR parts 15 and 1502, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies, public disclosure is governed by 5 U.S.C. 552 and 49 CFR parts 15 and 1502.

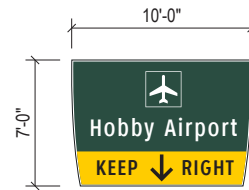
Series 4: Roadway Directionals - **Overhead** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

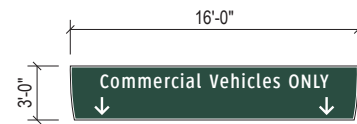
4-DR.01 to 4-DR.09 = OVERHEAD Directional Panels: No Header Panels



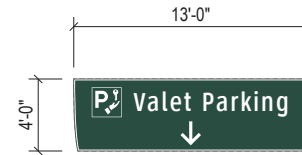
4-DR.01b 11'-0" W x 9'-0" H
1-Lane Panel
- 1 Arrow (20" ht.)
- 1 to 2 Message Lines (20" symbol; 14" text)
- Queue Text = 12" (if used)



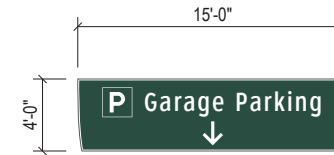
4-DR.01c 10'-0" W x 7'-0" H
1-Lane Panel
- 1 Arrow (18" ht.)
- 1 to 2 Message Lines (16" symbol; 12" text)
- Queue Text = 10" (if used)



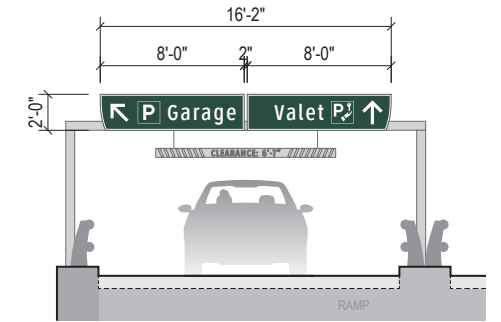
4-DR.06 Secondary 2-Lane Panel
- 2 Arrows (12" ht.)
- 1 Message Line (9" text)



4-DR.07 Overhead Building Mount
Valet Parking Entry Directional
- 1 Arrow (16")
- 1 Symbol (20")
- Text = 12"

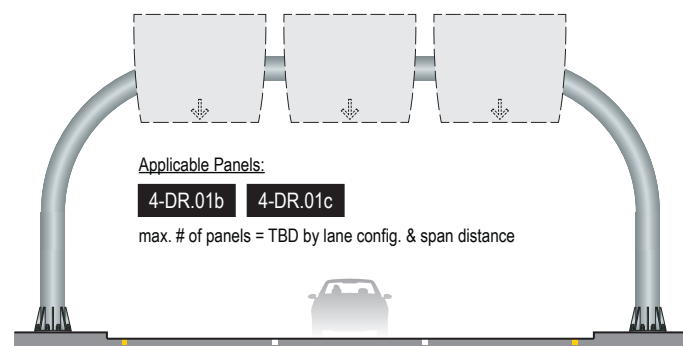


4-DR.07b Overhead Building Mount
Garage Entry Directional
- 1 Arrow (16")
- 1 Symbol (20")
- Text = 12"

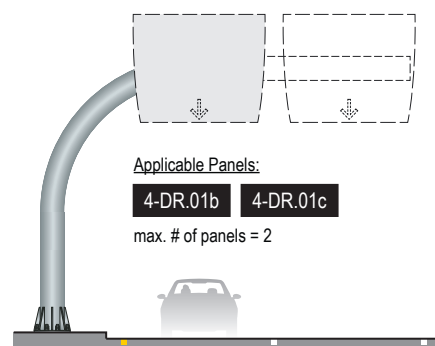


4-DR.08 Overhead Clearance Bar Mount
Valet/Garage Entry Directional
- 1 Arrow (16")
- 1 Symbol (15")
- Text = 10"

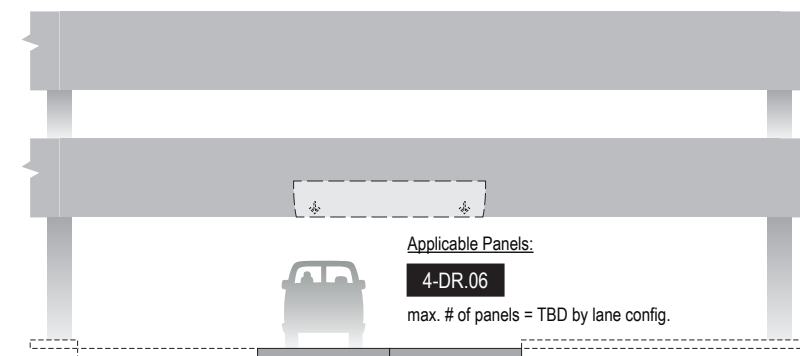
Span Monotube (Overhead Structure)



Cantilever Monotube (Overhead Structure)



Building Structure Mount



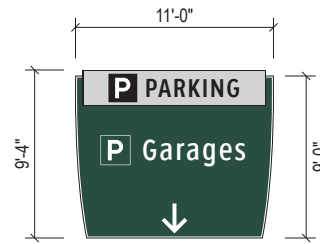
Mounting Options (SCALE: 1/16" = 1'-0")

NOTE: See "Chapter 3.0: Sign Location Plans & Message Schedules" for specific mounting types, configurations and orientations per individual sign locations

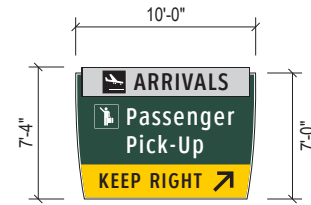
Series 4: Roadway Directionals - **Overhead** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

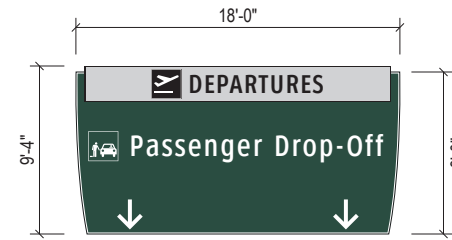
4-DR.10 to 4-DR.19 = OVERHEAD Directional Panels: With Header Panels



4-DR.11b 11'-0" W x 9'-4" H 1-Lane Panel w/ ID Header
 - 1 Arrow (20" ht.)
 - 1 to 2 Message Lines (20" symbol; 14" text)
 - ID Header Panel (24" H panel; 20" symbol; 12" text)
 - Alert Text = 12" (if used)



4-DR.11c 10'-0" W x 7'-4" H 1-Lane Panel w/ ID Header
 - 1 Arrow (18" ht.)
 - 1 to 2 Message Lines (16" symbol; 12" text)
 - ID Header Panel (20" H panel; 16" symbol; 11" text)
 - Alert Text = 10" (if used)

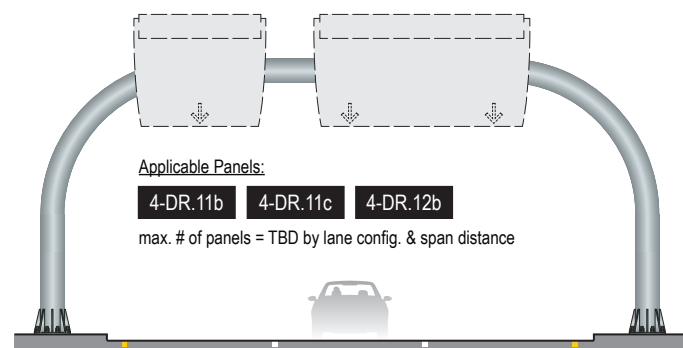


4-DR.12b 18'-0" W x 9'-4" H 2-Lane Panel w/ ID Header
 - 2 Arrows (20" ht. ea.)
 - 1 to 2 Message Lines (20" symbol; 14" text)
 - ID Header Panel (24" H panel; 20" symbol; 12" text)
 - Alert Text = 12" (if used)

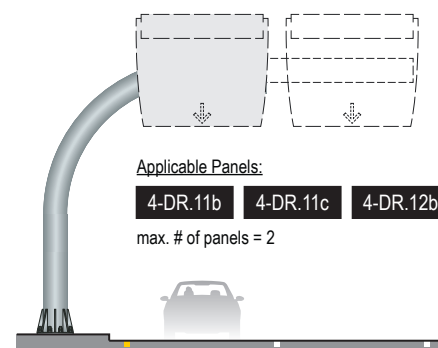


4-DR.12c 18'-0" W x 7'-4" H 2-Lane Panel w/ ID Header
 - 2 Arrow (18" ht. ea.)
 - 1 to 2 Message Lines (16" symbol; 11" text)
 - ID Header Panel (20" H panel; 16" symbol; 11" text)
 - Alert Text = 10" (if used)

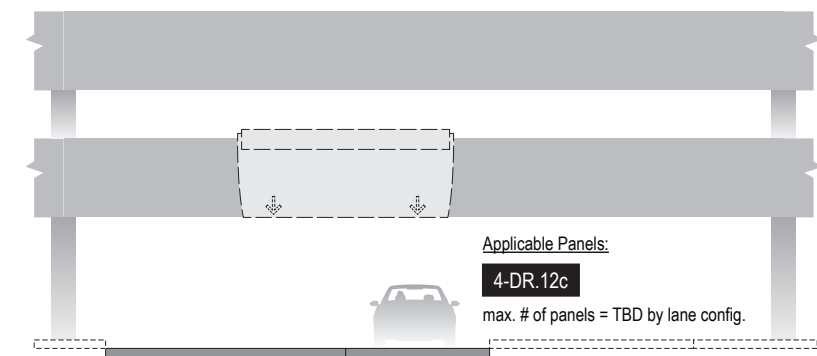
Span Monotube (Overhead Structure)



Cantilever Monotube (Overhead Structure)



Building Structure Mount



Mounting Options (SCALE: 1/16" = 1'-0")

NOTE: See "Chapter 3.0: Sign Location Plans & Message Schedules" for specific mounting types, configurations and orientations per individual sign locations

Series 4: Roadway Directionals - **Roadside** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

4-DR.20 to 4-DR.29 = ROADSIDE Directionals: No Header Panels

4-DR.25b 5' x 5' Roadside Cell Phone Lot Trailblazer

- 1 Post Mount
- 1 Arrow (14")
- 2 Symbols (14")
- 2 Message Lines (5" text)

4-DR.26b 5' x 5' Roadside Directional

- 1 Post Mount
- 1 Arrow (16")
- Messages/graphics vary per loc. (5" to 6" text)

4-DR.27b 5' x 5' Ramp Mount Valet Parking Directional

- 1 Post Mount
- 1 Arrow (16")
- Text = 8"; queue text = 6"

4-DR.28b 5' x 5' Roadside Directional w/ 2 Panels

- 2 Post Mount
- 2 Arrows (16")
- Messages/graphics vary per loc. (5" to 6" text)

4-DR.30 to 4-DR.39 = ROADSIDE Directionals: With Header Panels

4-DR.34 Roadside Directional w/ Header Panel

- 2 Post Mount
- Header Panel (12" H panel; 8" text)
- 1 Arrow (16")
- 1 to 2 Symbols (14")
- 1 to 2 Message Lines (8" text)

4-DR.36 Roadside Rental Car Trailblazer w/ 1 Panel

- 1 Panel @ 5' x 5'
- 1 Post Mount
- ID Header Panel (12" H panel; 10" symbol; 5" text)
- 1 Arrow (14")
- 1 to 3 Message Lines (5" text)
- Mileage Indicator = 7" text (if used)

4-DR.36b Roadside Rental Car Trailblazer w/ 2 Panels

- 2 Panels @ 5' x 5' ea.
- 1 Post Mount
- ID Header Panel (12" H panel; 10" symbol; 5" text)
- 2 Arrows, 1 per each panel (12")
- 1 to 3 Message Lines (10" to 12" 5" text)

Series 4: Roadway Identification / Informational - **Roadside** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

4-ID.10 to 4-ID.19 = ROADSIDE Identification - Airport Gateways

4-ID.11 Roadside Identification - Airport Gateway Monument
 - Airport ID letters = int. illum. channel letters
 - All other structural elements = up-lit

4-ID.20 to 4-ID.29 = ROADSIDE Identification: No Header Panels

4-ID.24b Roadside ID
 - 2 Post Mount
 - 1 Message Line (8" text)

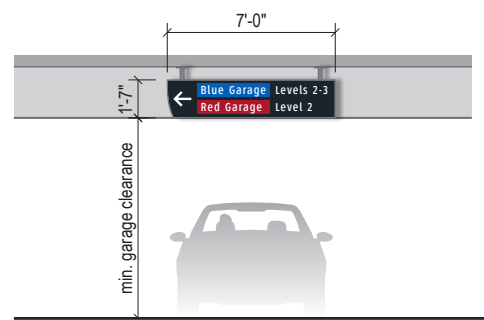
4-IN.11 to 4-IN.19 = ROADSIDE Informational - Welcome Monument

4-IN.11 Roadside Informational - Welcome to Houston Monument
 - "Welcome" ID letters = int. illum. channel letters
 - Dynamic backdrop display with up to 3 lines of message text

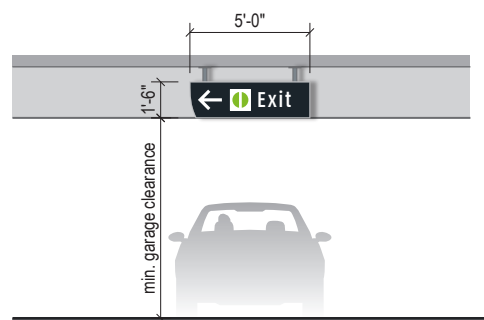
Series 5: Parking - Vehicular (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

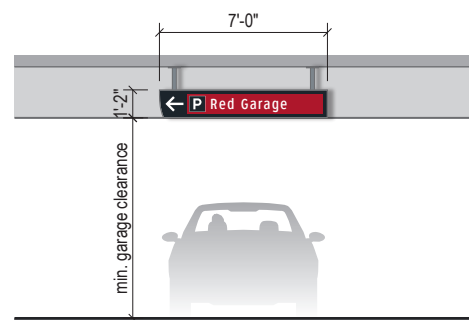
5-DR.01 to 5-DR.10 = Vehicular Directionals: CEILING Mount - Suspended



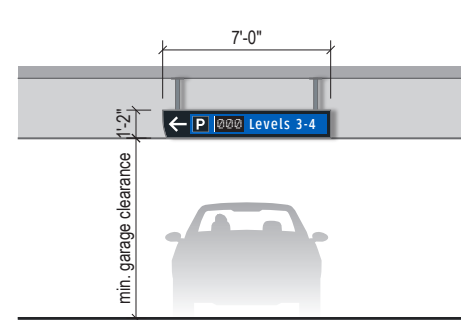
5-DR.02 Ceiling Suspended Directional - Vehicular
 - 1 direction; 2 Garage ID messages
 - Arrow = 12"
 - Text = 4"



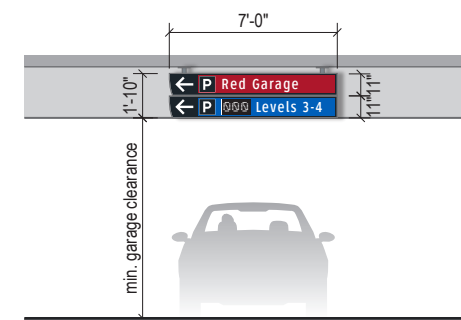
5-DR.03 Ceiling Suspended Exit Trailblazer - Vehicular
 - 1 direction; 1 message
 - Arrow = 12"
 - Symbol = 10.5"
 - Text = 7.5"



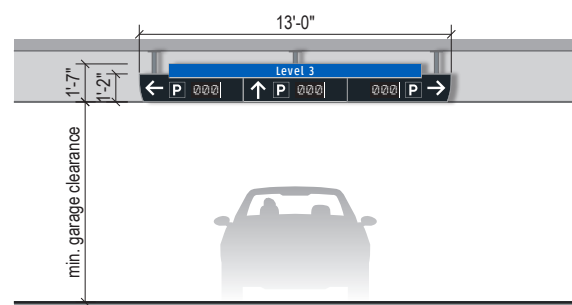
5-DR.04 Ceiling Suspended Directional - Vehicular
 - 1 direction; 1 message
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"



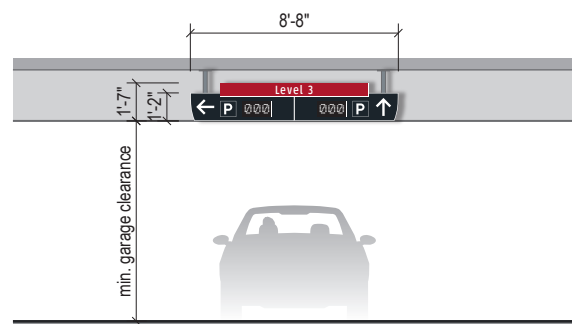
5-DR.05 Dynamic Ceiling Suspended Directional - Vehicular
 - 1 direction; 1 message
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)



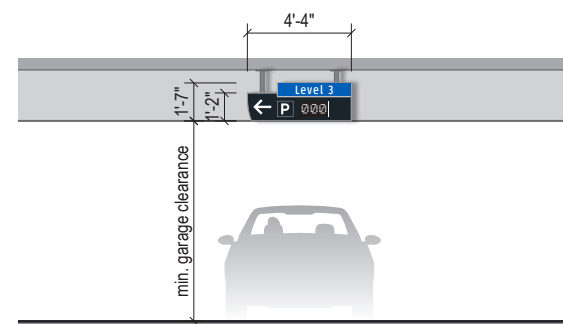
5-DR.05c Sm. Dynamic Ceiling Suspended Directional - Vehicular
 - Reduced height panels to fit stacked configuration within New Garage's beam height
 - 1 direction; 1 message
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)



5-DR.06 Dynamic Ceiling Suspended Directional w/ ID Header - Vehicular
 - 3 directions; 1 message per direction
 - ID Header Panel (7" H panel; 4" text)
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)



5-DR.07 Dynamic Ceiling Suspended Directional w/ ID Header - Vehicular
 - 2 directions; 1 message per direction
 - ID Header Panel (7" H panel; 4" text)
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

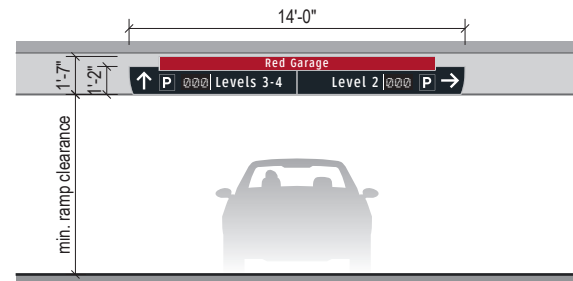


5-DR.08 Dynamic Ceiling Suspended Directional w/ ID Header - Vehicular
 - 1 direction; 1 message
 - ID Header Panel (7" H panel; 4" text)
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

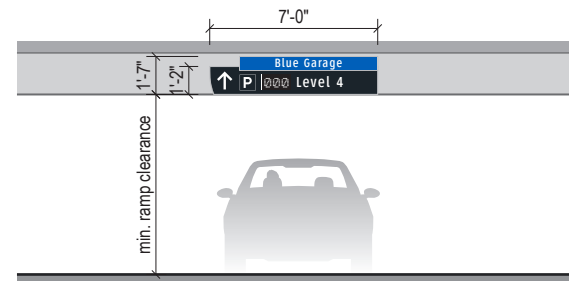
Series 5: Parking - Vehicular (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

5-DR.10 to 5-DR.19 = Vehicular Directionals: WALL / BEAM / SOFFIT Mount



5-DR.17 Dynamic Beam Mounted Ramp Directional w/ ID Header - Vehicular
 - 2 directions; 1 message per direction
 - ID Header Panel (7" H panel; 4" text)
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

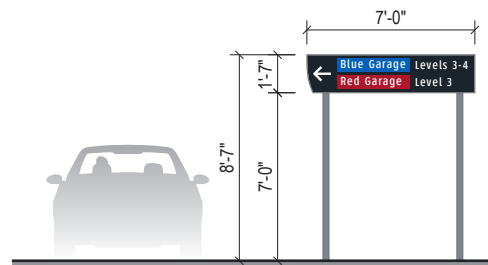


5-DR.18 Dynamic Beam Mounted Ramp Directional w/ ID Header - Vehicular
 - 1 direction; 1 message per direction
 - ID Header Panel (7" H panel; 4" text)
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

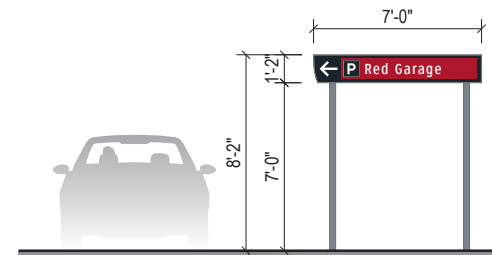


5-DR.18b
 Right-facing panel variant

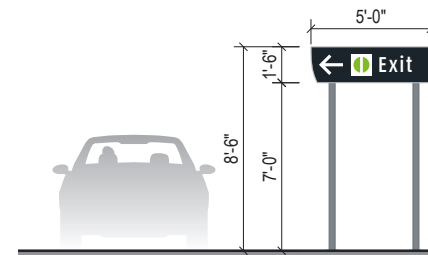
5-DR.50 to 5-DR.59 = Vehicular Directionals: ROADSIDE



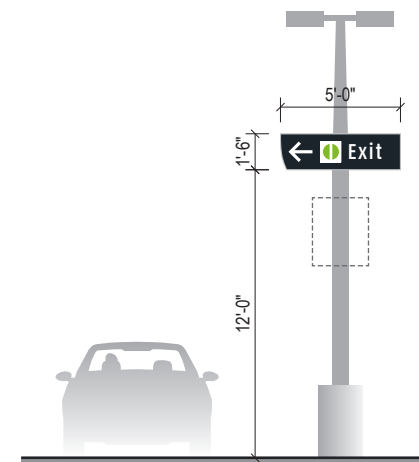
5-DR.51 Roadside Directional - Vehicular
 - 2 Post Mount
 - 1 direction; 2 Garage ID messages
 - Arrow = 9"
 - Text = 4"



5-DR.52 Roadside Directional - Vehicular
 - 2 Post Mount
 - 1 direction; 1 message
 - Arrow = 9"
 - Symbol = 8"
 - Text = 5"

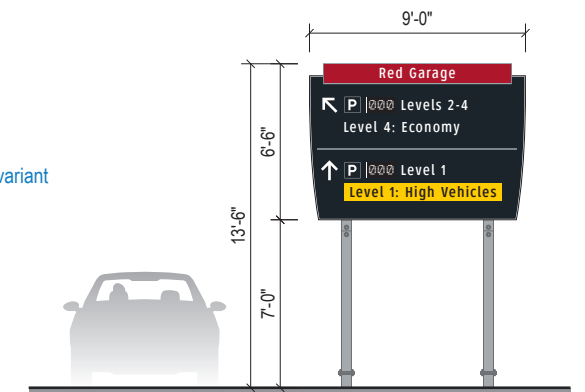


5-DR.53 Roadside Exit Trailblazer - Vehicular
 - 2 Post Mount
 - 1 direction; 1 message
 - Arrow = 12"
 - Symbol = 10.5"
 - Text = 7.5"



5-DR.54 Light Post Mount Exit Trailblazer - Vehicular
 - Light Post Mount
 - 1 direction; 1 message
 - Arrow = 12"
 - Symbol = 10.5"
 - Text = 7.5"

5-DR.54b
 Right-facing panel variant

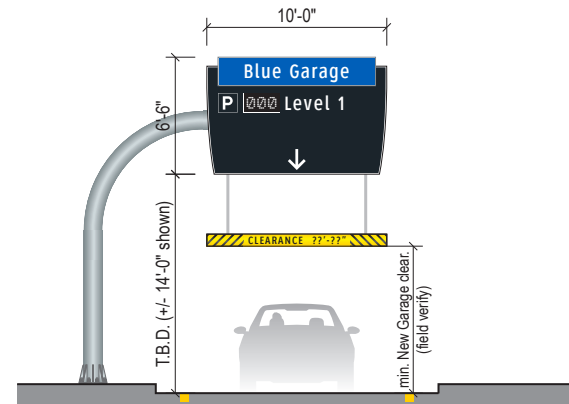


5-DR.55 Dynamic Roadside Garage Entry Directional - Vehicular
 - 2 Post Mount
 - 2 directions; 1-2 messages per direction
 - ID Header Panel (10" H panel; 5" text)
 - Arrow = 10"
 - Symbol = 8"
 - Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

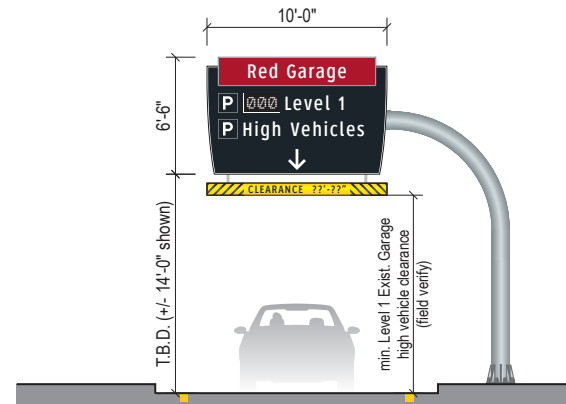
Series 5: Parking - Vehicular (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

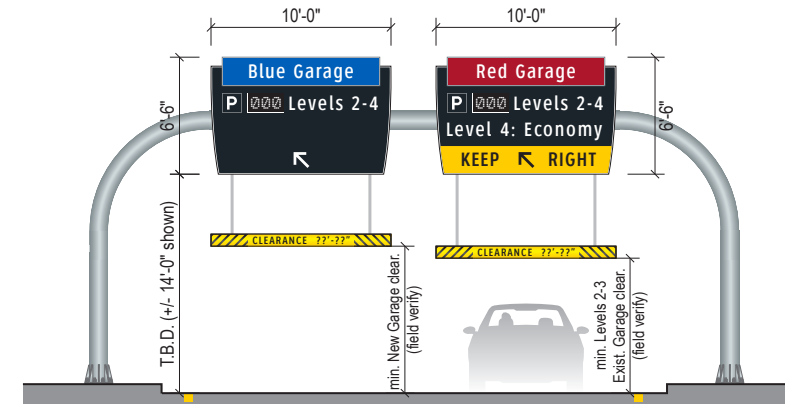
5-DR.60 to 5-DR.69 = Vehicular Directional: OVERHEAD SPAN / CANTILEVER Mount



- 5-DR.61** 1-Message Cantilever Garage Facility Entry Directional - Vehicular
- Overhead Cantilever Monotube Mount
 - 1 Panel (1 direction; 1 message)
 - ID Header Panel (1'-7" H panel; 9" text)
 - Arrow = 1'-2"
 - Symbol = 1'-1"
 - Text = 9"
 - Dynamic No.'s = TBD (9" min. ht. planned)
 - 8" round tube clearance bar (6" text) on chains

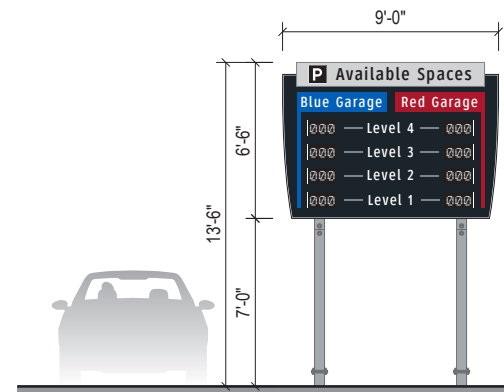


- 5-DR.61b** 2-Message Cantilever Garage Facility Entry Directional - Vehicular
- Overhead Cantilever Monotube Mount
 - 1 Panel (1 direction; 2 messages)
 - ID Header Panel (1'-7" H panel; 9" text)
 - Arrow = 1'-2"
 - Symbol = 1'-1"
 - Text = 9"
 - Dynamic No.'s = TBD (9" min. ht. planned)
 - 8" round tube clearance bar (6" text) on chains



- 5-DR.62** Overhead Span Garage Ramp Entry Directional - Vehicular
- Overhead Span Monotube Mount
 - 2 Panels (1 direction; 1-2 messages per panel)
 - ID Header Panel (1'-7" H panel; 9" text)
 - Arrow = 1'-2"
 - Symbol = 1'-1"
 - Text = 9"
 - Dynamic No.'s = TBD (9" min. ht. planned)
 - 8" round tube clearance bar (6" text) on chains

5-IN.50 to 5-IN.59 = Vehicular Informational: ROADSIDE

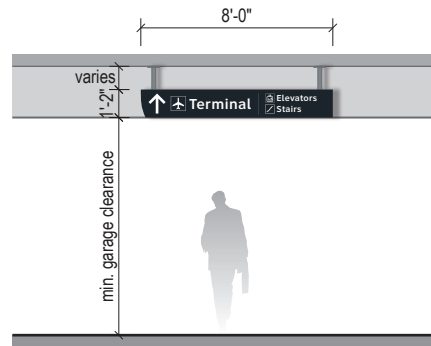


- 5-IN.56** Dynamic Roadside Garage Space Informational - Vehicular
- 2 Post Mount
 - ID Header Panel (10" H panel; 9" symbol; 6" text)
 - Garage ID & Level No. Text = 5"
 - Dynamic No.'s = TBD (5" min. ht. planned)

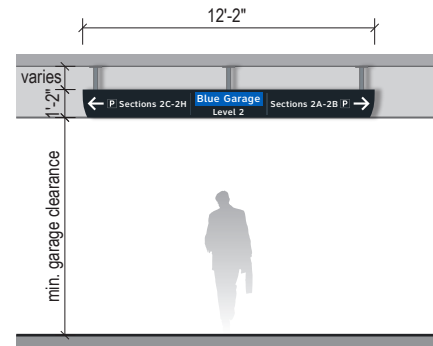
Series 5: Parking - Blue (New) Garage Areas - **Pedestrian** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

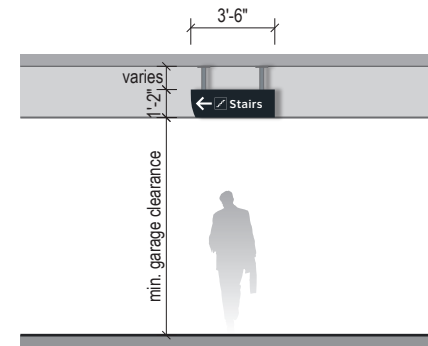
5-DR.30 to 5-DR.39 = Pedestrian Directionals: **CEILING** Mount - **Suspended**



5-DR.31b Lg. Ceiling Suspended Terminal/Elevator Trailblazer - Pedestrian
 - Arrow = 10"
 - Terminal ID: symbol = 7.5"; text = 5"
 - Elevators/Stairs: symbol = 5"; text = 3"

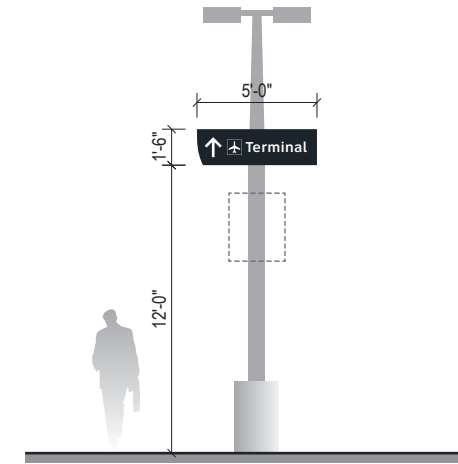


5-DR.34 Ceiling Suspended Terminal/Sections Directional - Pedestrian
 - Center ID panel for Terminal or Garage ID
 - 2 direction; 1-2 messages per direction
 - Arrow = 8"
 - Symbol = 5"
 - Text = 3"



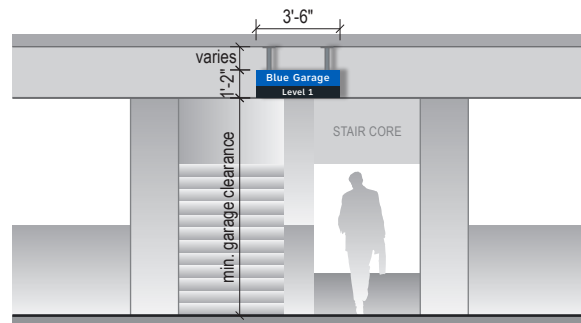
5-DR.35 Ceiling Suspended Stairs Directional - Pedestrian
 - 1 direction; 1 message
 - Arrow = 8"
 - Symbol = 6"
 - Text = 4"

5-DR.40 to 5-DR.49 = Pedestrian Directionals: **POST** Mount



5-DR.41 Light Post Mount Terminal Trailblazer - Pedestrian
 - Arrow = 10"
 - Symbol = 7.5"
 - Text = 5"

5-ID.30 to 5-ID.39 = Pedestrian Identification: **CEILING** Mount - **Suspended**



5-ID.36 Ceiling Suspended Stair Core Level ID - Pedestrian
 - "Blue Garage" text = 4"
 - Level no. text = 3"

Series 5: Parking - Blue (New) Garage Areas - Pedestrian (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

5-ID.40 to 5-ID.49 = Pedestrian Identification: POST Mount

5-ID.41 Light Post-Wrap Parking Section/Garage ID - Pedestrian
 - 4-sided config. w/ 4 panels mounted to fabricated light post wrap-frame
 - "Blue" text = 4" - "Garage" text = 2.5"
 - "Section" text = 3" - Section no. text = 5"

5-ID.41b
 4-sided config. w/ panels mounted to fabricated post mount frame (no light post)

5-ID.50 to 5-ID.59 = Pedestrian Identification: COLUMN / WALL Mount

@ Levels 1, 2 & 3

5-ID.51 Column-Wrap Parking Section/Garage ID - Pedestrian
 - 4-sided config. w/ 4 panels mounted to fabricated column wrap-frame on 2'-0" square columns
 - "Blue" text = 4"
 - "Garage" text = 2.5"
 - "Section" text = 3"
 - Section no. text = 5"

5-ID.51d
 1-sided config. w/ 1 individual panel direct mount on column face (no wrap-frame)

5-ID.51e
 4-sided config. w/ 4 individual panels direct mount on wider 2'-8" column faces (no wrap-frame)

5-ID.50 to 5-ID.59 = Pedestrian Identification: COLUMN / WALL Mount (cont.)

5-ID.52c Wall Mount Elevator Lobby Entrance/Level ID - Pedestrian
 - "Elevators" text = 6.5"
 - "Blue Garage Level" text = 5"
 - Level no. text = 2'-6"

5-ID.52d
 RIGHT-Side variant

5-ID.60 to 5-ID.69 = Pedestrian Elevator ID/Info & ADA Plaques: WALL Mount

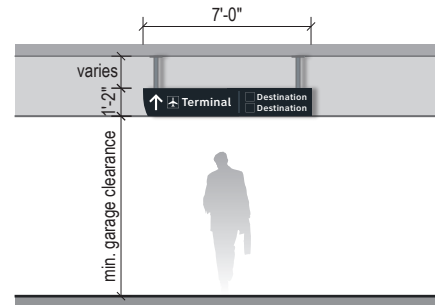
5-ID.60 Wall Mount ADA Tactile Standard Room ID - Pedestrian
 - All text/graphic sizing & tactile elements per ADA

5-ID.65 Wall Mount Level ID @ Elevators

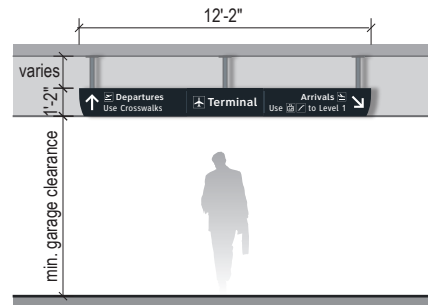
Series 5: Parking - Red (Existing) Garage Areas - **Pedestrian** (Scale: 1/8" = 1'-0")

NOTE: Sizes shown are typical only; parking conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

5-DR.30 to 5-DR.39 = Pedestrian Directionals: **CEILING** Mount - **Suspended**

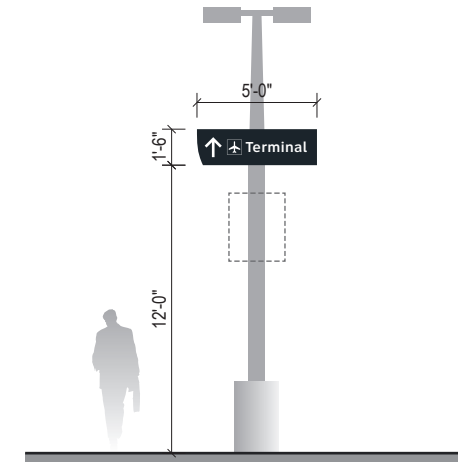


5-DR.31 Ceiling Suspended Terminal/Garage Trailblazer - Pedestrian
 - Arrow = 8"
 - Terminal ID: symbol = 6"; text = 4"
 - Garage ID: text = 3.5"
 - Destinations: symbol = 5"; text = 3"



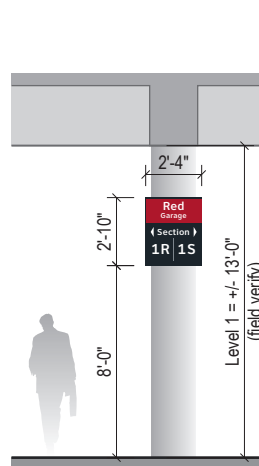
5-DR.34 Ceiling Suspended Terminal/Sections Directional - Pedestrian
 - Center ID panel for Terminal and/or Garage ID
 - 2 direction; 1-2 messages per direction
 - Arrow = 8"
 - Symbol = 5"
 - Text = 3"

5-DR.40 to 5-DR.49 = Pedestrian Directionals: **POST** Mount

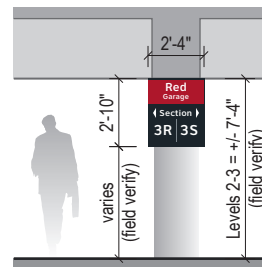


5-DR.41 Light Post Mount Terminal Trailblazer - Pedestrian
 - Arrow = 10"
 - Symbol = 7.5"
 - Text = 5"

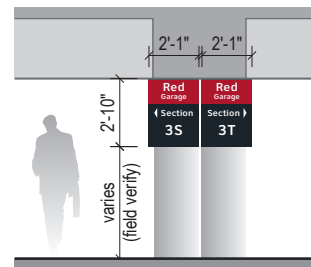
5-ID.50 to 5-ID.59 = Pedestrian Identification: **COLUMN / WALL / FLOOR** Mount



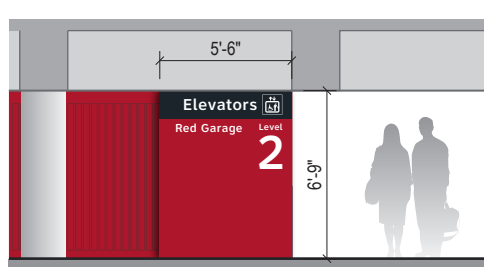
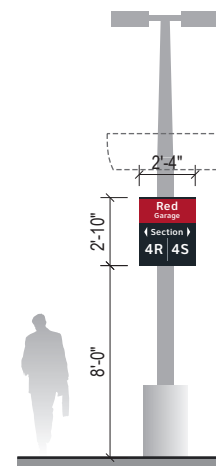
5-ID.51 Column-Wrap Parking Section/Garage ID - Pedestrian
 - 4 Sides
 - "Blue" text = 4"
 - "Garage" text = 2.5"
 - "Section" text = 3"
 - Section no. text = 5"



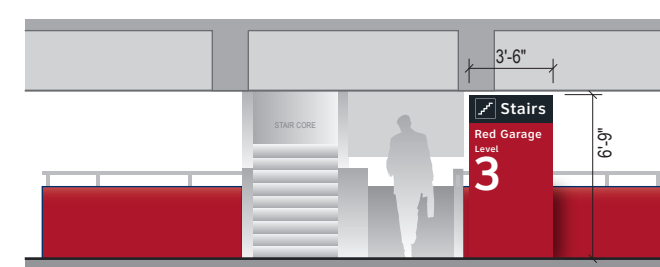
5-ID.51b Double Column Expansion Joints



5-ID.51c Garage Roof

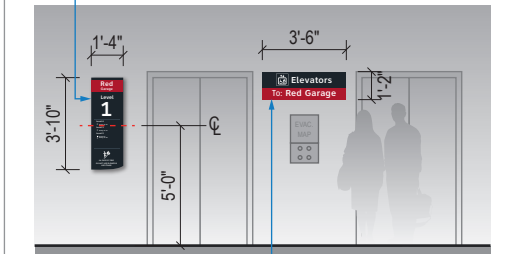


5-ID.52 Wall Mount Elevator Core Level ID - Pedestrian
 - "Elevators" text = 6"
 - "Blue Garage" text = 4"
 - Level no. text = 16.5"



5-ID.60 to 5-ID.69 = Elevator ID/Info: **WALL** Mount

5-ID.65 Wall Mount Level ID @ Elevators



5-ID.66 Wall Mount ID @ Vertical Core Entries



HAS WAYFINDING SYSTEM

Signage Design Guidelines, Standards and Typical Applications

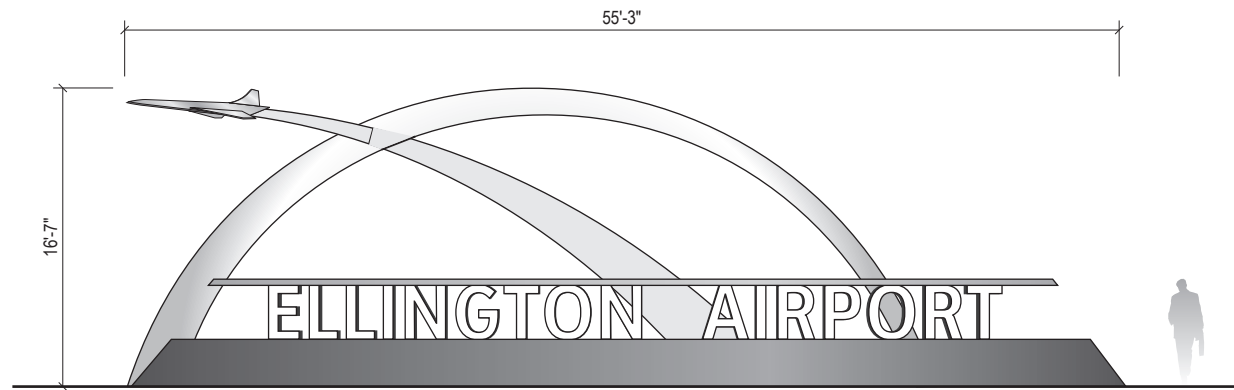
VOLUME 4.0

4.1 Wayfinding Sign Families - EFD

Series 4: Roadway Identification / Informational - **Roadside** (Scale: 3/32" = 1'-0")

NOTE: Sizes shown are typical only; roadway conditions vary and may require adjustment for final design of sign type sizing/proportions; additional sign types may also be required as determined during individual HAS improvement programs

4-ID.10 to 4-ID.19 = **ROADSIDE** Identification - Airport Gateways



4-ID.11 Roadside Identification - Airport Gateway Monument
 - Airport ID letters = int. illum. channel letters
 - All other structural elements = up-lit



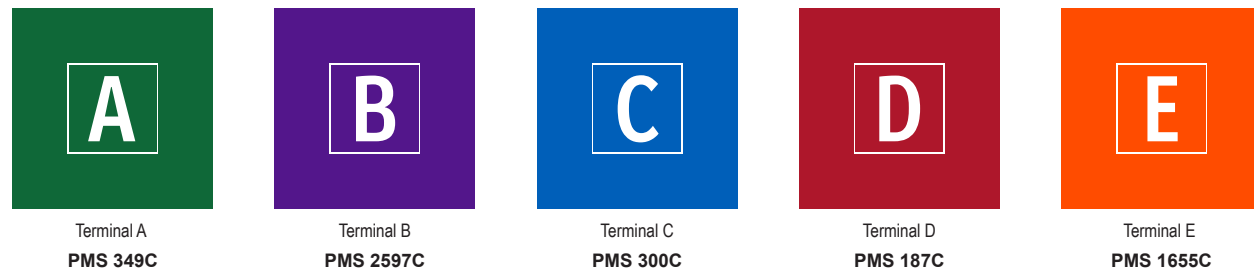
HAS WAYFINDING SYSTEM

Signage Design Guidelines, Standards and Typical Applications

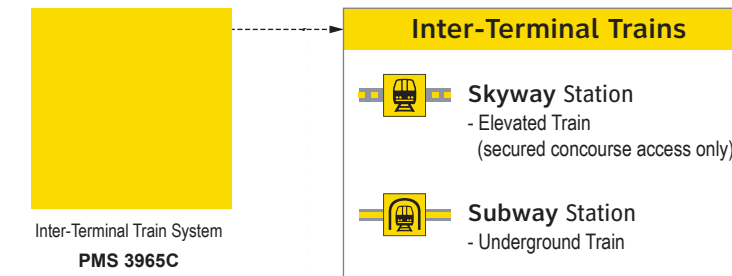
VOLUME 5.0

5.1 Appendix

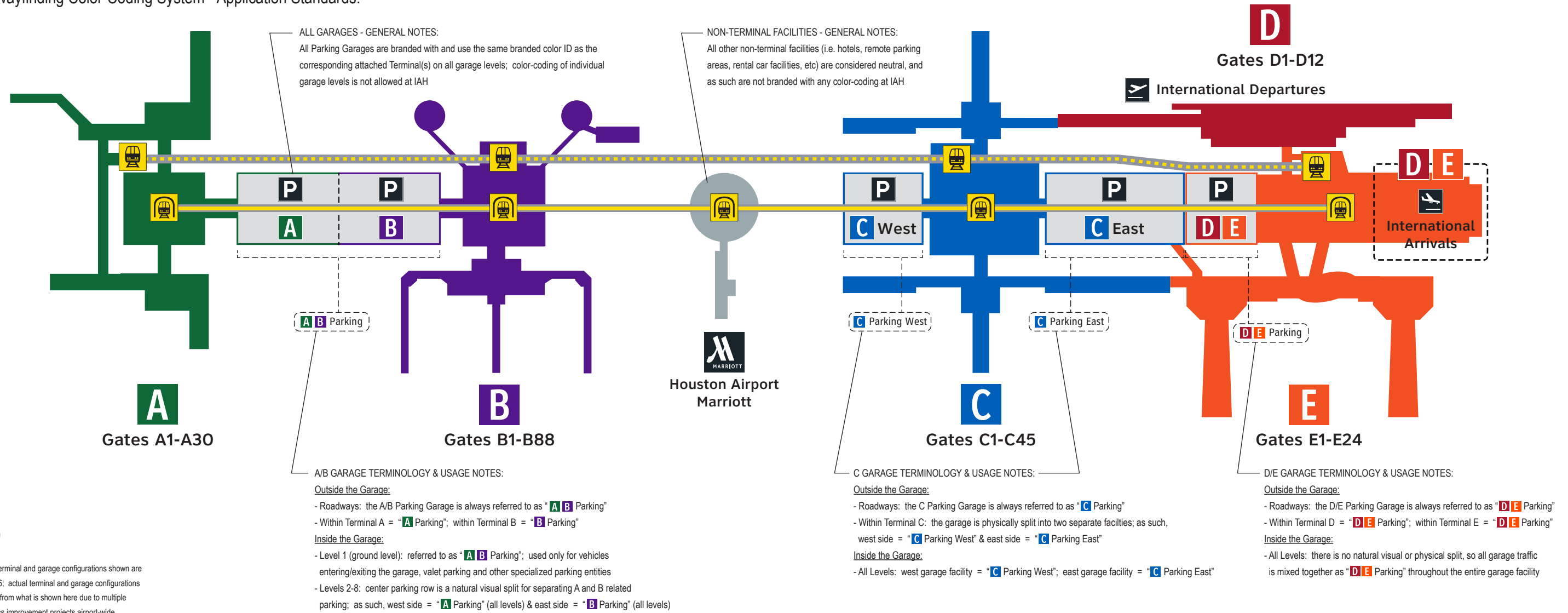
Branded Terminal Identification:



Branded Inter-Terminal Train Identification:



IAH Wayfinding Color-Coding System - Application Standards:



Wayfinding Color-Coding: IAH Branded Identification and Application

HAS WAYFINDING COLOR SYSTEM

In order to maintain a visually and graphically holistic system of wayfinding signage, the presentation of color must always be consistent and maintained on all elements of HAS wayfinding signage. These colors and their manufacturing equivalents (as shown in Figure 1.3.12) shall always be used when designing or specifying HAS wayfinding signage, unless otherwise noted and approved by HAS.

UNIVERSAL COLORS: All HAS Airport Properties												
Hardware/HOU Accent:	Gateways - Dark Silver:	Gateways - Dark Bronze:	White Graphics:	Sign Face Backgrounds:	Divider-Line Graphics:	Neutral Watermark:	ID Header Background:	Black Graphics:	Safety Red:	Warning Yellow:	DOT Legend Green:	
PMS1 (Pantone Matching System Ref.) N/A: Not Used	PMS2 (Pantone Matching System Ref.) N/A: Not Used	PMS3 (Pantone Matching System Ref.) N/A: Not Used	PMS4 (Pantone Matching System Ref.) N/A: Not Used	PMS5 (Pantone Matching System Ref.) PMS 433C (Solid Coated)	PMS6 (Pantone Matching System Ref.) PMS 432C (Solid Coated)	PMS7 (Pantone Matching System Ref.) PMS 430C (Solid Coated)	PMS8 (Pantone Matching System Ref.) PMS 427C (Solid Coated)	PMS9 (Pantone Matching System Ref.) PMS Black C (Solid Coated)	PMS10 (Pantone Matching System Ref.) PMS 186C (Solid Coated)	PMS11 (Pantone Matching System Ref.) PMS 116C (Solid Coated)	PMS12 (Pantone Ref.) PMS 342C (Solid Coated)	PMS12.2 (Pantone Ref.) N/A: Note Used
D1 (Digital Print Equivalent) N/A: Not Used	D2 (Digital Print Equivalent) N/A: Not Used	D3 (Digital Print Equivalent) N/A: Not Used	D4 (Digital Print Equivalent) White = C:0 M:0 Y:0 K:0; Roadway signs = 3M 4090 DG3 White (showing thru)	D5 (Digital Print Equivalent) Match PMS 433C; Roadway signs = Picasso print on DG3 C:0 M:0 Y:0 K:90 (cool gray row)	D6 (Digital Print Equivalent) Match PMS 432C	D7 (Digital Print Equivalent) Match PMS 430C	D8 (Digital Print Equivalent) Match PMS 427C; Roadway signs = Picasso print on DG3 C:0 M:0 Y:0 K:100 (cool gray row)	D9 (Digital Print Equivalent) C:50 M:40 Y:40 K:100; Roadway signs = Picasso print on DG3 C:0 M:0 Y:0 K:100 (cool gray row)	D10 (Digital Print Equivalent) Match PMS 186C	D11 (Digital Print Equivalent) Match PMS 116C	D12 (Digital Print Eq.) Match PMS 342C	D12.2 (Digital Print Eq.) Match "Waller Green" custom color
P1 (Gateway Paint Eq.) Matthews Acrylic Polyurethane (MAP) #41342SP Brushed Aluminum, satin finish	P2 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) #MP32195 Staid Gray Metallic, satin finish	P3 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) #41313SP Dark Bronze, satin finish	P4 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) MP N202 White, satin finish	P5 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 433C, satin finish	P6 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 432C, satin finish	P7 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 430C, satin finish	P8 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 427C, satin finish	P9 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match TBD, satin finish	P10 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 186C, satin finish	P11 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 116C, satin finish	P12 (Paint Eq.) MAP to match PMS 342C, satin fin.	P12.2 (Paint Eq.) MAP to match "Waller Green," satin fin.
P1.2 (HOU/EFD Accent Paint) Matthews Acrylic Polyurethane (MAP) #MP33172 Silver Surfer Metallic, satin fin.	V2 (Vinyl Film Equivalent) N/A: Not Used	V3 (Vinyl Film Equivalent) N/A: Not Used	V4.x (NOTE: "x" = see below) (Vinyl Film Equivalent) V4.1 = Opaque: 3M 7725-20 White V4.2 = Reflective: 3M 4090 DG3 White T4.3 = Tactile: White to match V4.1 V4.4 = Translucent: White plex to match V4.1	V5 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V6 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V7 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V8 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V9 (Vinyl Film Equivalent) Opaque: 3M 7725-22 Black	V10 (Vinyl Film Equivalent) Reflective: 3M 4092 DG3 Red	V11 (Vinyl Film Equivalent) Reflective: 3M 4091 DG3 Yellow	V12 (Vinyl Film Eq.) Reflective: 3M 4097 DG3 Green	V12.2 (Vinyl Film Eq.) Ref.: Use Digital Print Eq. on White film
NOTE: Also used only on HOU roadway signs												
TERMINAL BRANDED ID COLORS: IAH Only												
PMS13 (Pantone Matching System Ref.) PMS 349C (Solid Coated)	PMS14 (Pantone Matching System Ref.) PMS 3435C (Solid Coated)	PMS15 (Pantone Matching System Ref.) PMS 2597C (Solid Coated)	PMS16 (Pantone Matching System Ref.) PMS 2695C (Solid Coated)	PMS17 (Pantone Matching System Ref.) PMS 300C (Solid Coated)	PMS18 (Pantone Matching System Ref.) PMS 294C (Solid Coated)	PMS19 (Pantone Matching System Ref.) PMS 187C (Solid Coated)	PMS20 (Pantone Matching System Ref.) PMS 188C (Solid Coated)	PMS21 (Pantone Matching System Ref.) PMS 1655C (Solid Coated)	PMS22 (Pantone Matching System Ref.) PMS 180C (Solid Coated)	PMS23 (Pantone Matching System Ref.) PMS 3965C (Solid Coated)	PMS24 (Pantone Matching System Ref.) PMS 3975C (Solid Coated)	
D13 (Digital Print Equivalent) Match PMS 349C; Roadway signs = Picasso print on DG3 C:90 M:50 Y:90 K:0	D14 (Digital Print Equivalent) Match PMS 3435C	D15 (Digital Print Equivalent) Match PMS 2597C; Roadway signs = Picasso print on DG3 C:70 M:100 Y:0 K:0	D16 (Digital Print Equivalent) Match PMS 2695C	D17 (Digital Print Equivalent) Match PMS 300C; Roadway signs = Picasso print on DG3 C:100 M:50 Y:0 K:0	D18 (Digital Print Equivalent) Match PMS 294C	D19 (Digital Print Equivalent) Match PMS 187C; Roadway signs = Picasso print on DG3 C:30 M:100 Y:80 K:0	D20 (Digital Print Equivalent) Match PMS 188C	D21 (Digital Print Equivalent) Match PMS 1655C; Roadway signs = Picasso print on DG3 C:0 M:70 Y:100 K:0	D22 (Digital Print Equivalent) Match PMS 180C	D23 (Digital Print Equivalent) Match PMS 3965C	D24 (Digital Print Equivalent) Match PMS 3975C	
P13 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 349C, satin finish	P14 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 3435C, satin finish	P15 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 2597C, satin finish	P16 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 2695C, satin finish	P17 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 300C, satin finish	P18 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 294C, satin finish	P19 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 187C, satin finish	P20 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 188C, satin finish	P21 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 1655C, satin finish	P22 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 180C, satin finish	P23 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 3965C, satin finish	P24 (Paint Equivalent) Matthews Acrylic Polyurethane (MAP) to match PMS 3975C, satin finish	
V13 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V14 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V15 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V16 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V17 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V18 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V19 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V20 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V21 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V22 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V23 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	V24 (Vinyl Film Equivalent) Use Digital Print Equivalent on White film	
NOTE: Also used as HOU - Ecopark (Parking Lot) ID				NOTE: Also used as HOU - Blue (aka "New") Garage ID				NOTE: Also used as HOU - Red (aka "Existing") Garage ID				

IAH Wayfinding Color System

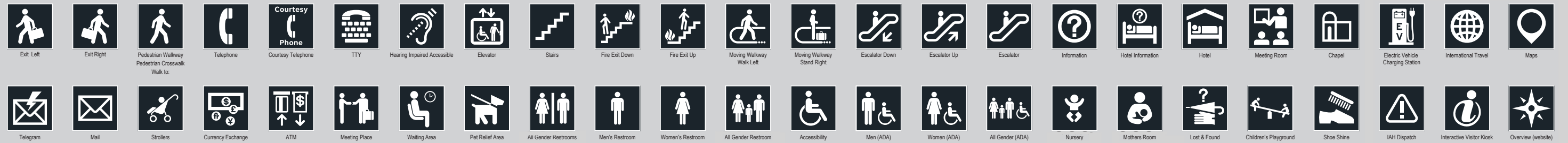
TRAVEL SYMBOLS



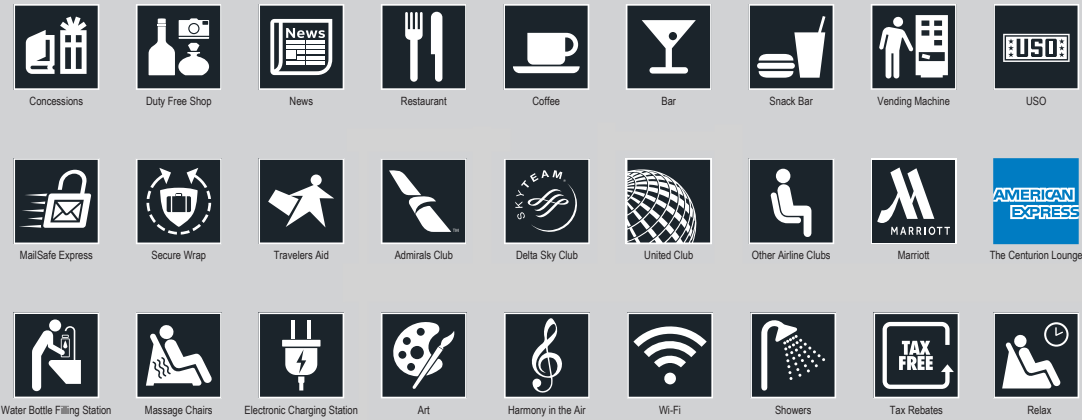
INTER-TERMINAL TRAINS: IAH Only



PUBLIC SERVICE SYMBOLS



AMENITIES & CONCESSIONS



GROUND TRANSPORTATION



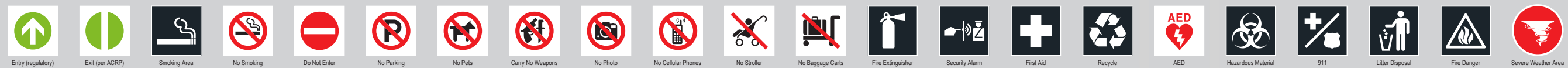
TERMINAL IDENTIFICATION: IAH Only



TXDOT HIGHWAY SHIELDS



REGULATORY


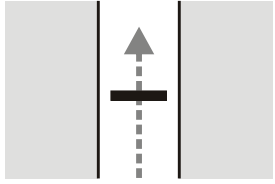

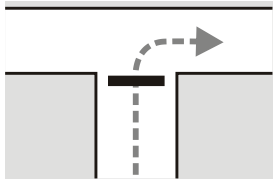

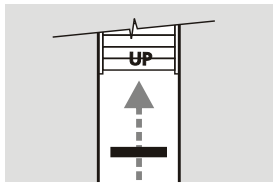

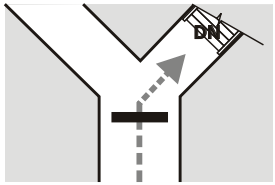

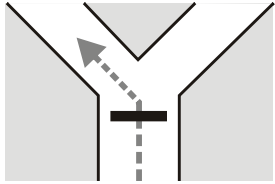

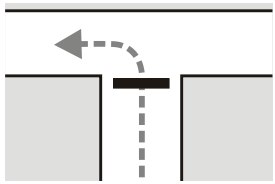

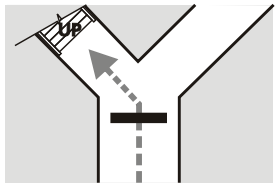

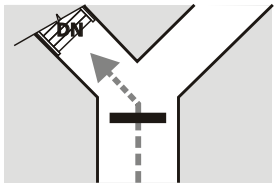

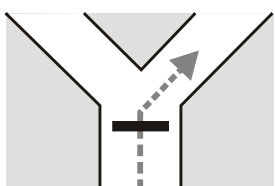

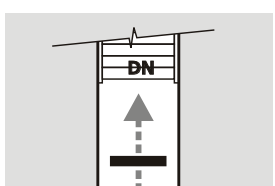

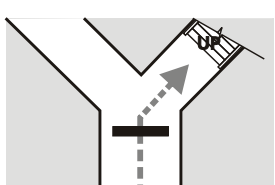

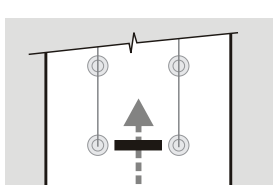


NOTE: Use only this HAS wayfinding universal symbol artwork as shown; re-proportioning and/or manipulating is not allowed

UPDATED: 02-19-2018

These documents are intended to provide design intent and should only be used as a general guideline. No information contained herein should be construed as a guarantee or warranty. The individual contractor shall be responsible for all engineering and specifications with regard to structural, electrical, mechanical, foundation and installation.

WARNING:
 This second edition contains security information that is controlled under 48 CFR parts 101 and 102. The user of this second edition should be aware that it is "need to know" as defined in 48 CFR parts 101 and 102, and that it is the property of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalties or other action. For U.S. government agencies, public disclosure is governed by 5 U.S.C. 552 and 48 CFR parts 101 and 102.

ARROW ROTATION	LOCATION PLAN EXAMPLE	MESSAGE CONVEYED	ARROW ROTATION	LOCATION PLAN EXAMPLE	MESSAGE CONVEYED
 90° (12 o'clock)		Straight Ahead	 0° (3 o'clock)		Right
 90° (12 o'clock)		Up	 315° (4:30)		Down on the Right
 135° (10:30)		Ahead on the Left	 180° (9 o'clock)		Left
 135° (10:30)		Up on the Left	 225° (7:30)		Down on the Left
 45° (1:30)		Ahead on the Right	 270° (6 o'clock)		Down
 45° (1:30)		Up on the Right	 270° (6 o'clock)		Use this lane / row / aisle / line

NOTES:
 - Source: Guidelines for Airport Signage & Graphics - Latest Ed.
 - Schematic representations only; drawings not to scale

Wayfinding Arrows: Applications - Pedestrian

OVERHEAD Directionals		
ARROW ROTATION	LOCATION PLAN EXAMPLE	MESSAGE CONVEYED
 90° (12 o'clock)		Straight Ahead (Arrow Justified Center)
 270° (6 o'clock)		Straight Ahead: Use This Lane (Arrow Justified Center)
 315° (4:30)		Down on the Right (Arrow Justified Center)
 225° (7:30)		Down on the Left (Arrow Justified Center)
 45° (1:30)		Exit/Ahead on the Right (Arrow Justified Center)
 135° (10:30)		Exit/Ahead on the Left (Arrow Justified Center)

CANTILEVER Directionals		
ARROW ROTATION	LOCATION PLAN EXAMPLE	MESSAGE CONVEYED
 90° (12 o'clock)		Straight Ahead (Arrow Justified Center)
 90° (12 o'clock)		Straight Ahead (Arrow Justified Center)
 270° (6 o'clock)		Straight Ahead: Use This Lane (Arrow Justified Center)
 270° (6 o'clock)		Straight Ahead: Use This Lane (Arrow Justified Center)
 135° (10:30)		Exit/Ahead on the Left (Arrow Justified Center)
 45° (1:30)		Exit/Up on the Right (Arrow Justified Center)

ROADSIDE Directionals		
ARROW ROTATION	LOCATION PLAN EXAMPLE	MESSAGE CONVEYED
 90° (12 o'clock)		Straight Ahead (Arrow Justified Left)
 90° (12 o'clock)		Straight Ahead (Arrow Justified Right)
 45° (1:30)		Exit/Ahead on the Right (Arrow Justified Right)
 0° (3:00)		To the Right (Arrow Justified Right)
 135° (10:30)		Exit/Ahead on the Left (Arrow Justified Left)
 180° (9 o'clock)		To the Left (Arrow Justified Left)

NOTES:
 - Arrow applications shown are for general reference only
 - Arrow type and application may vary based on condition
 - Reference MUTCD for additional standards and guidelines

Wayfinding Arrows: Applications - Vehicular

47- GATE MARKINGS



47 - Gate Markings

Part 1 - General

1.1. Overview

- 1.1.1. The purpose of this standard is to provide a guide and minimum requirements for gate markings to promote safety and operational reliability. It is to be used as a tool for the planning and design of gate markings and layout. It is the responsibility of the designer to ensure that the gates meet all required standards and that the gate layout complies with the requirements of the current and/or projected fleet mix.
- 1.1.2. Gate markings should be reviewed for compliance if there is a change to the fleet mix, gate relocation (permanent or temporary), and/or a passenger boarding bridge replacement.
- 1.1.3. Any proposed modifications to existing gate markings should be reviewed by the HAS project manager, airport operations, and any other key stakeholders through HAS design review process prior to final approved plans and acceptance in the field. Upon completion of the markings in the field, final as-built conditions shall be surveyed and collected in both PDF and CAD format and provided to HAS.

1.2. General Requirements

- 1.2.1. The planning process for each gate should consider all aspects of aircraft servicing and specific fleet mix requirements. Criteria within this section represents a generic layout for various aircrafts.
- 1.2.2. Aircraft Clearances and Operational Safety Zone (OSZ) – Minimum distances or OSZ should be established between the aircraft and other objects or facilities. This OSZ is to establish a minimum criterion to help project the aircraft and ground servicing equipment (GSE) from potential damage (see **Figure 1**). The following criteria can be superseded by FAA regulations when more stringent. Any special cases are to be reviewed by HAS on a case-by-case basis and approved by Change Review Committee.

OSZ Clearances:

- A minimum distance of 10 feet from the fuselage of the aircraft.
- A minimum distance of 15 feet from the leading edge of the aircraft's wing.
- A minimum distance of 2.5 feet from the edge of the wing/winglet tip
- A minimum distance of 15 feet should be provided from the engine or propeller of the aircraft.

Aircraft Clearances:

- A minimum distance of 25 feet from the nose of the design aircraft to the nearest facility or object.
- A minimum distance of 25 feet from the outermost portion of the wing to that of an adjacent aircraft.
- A minimum distance of 5 feet from the outermost edge of the aircraft to the vehicle service road (VSR). In the case of a service road in parallel to the safety envelope, a minimum distance of 5 feet should be kept from the edge marking of the VSR and the outermost edge of the safety envelope.

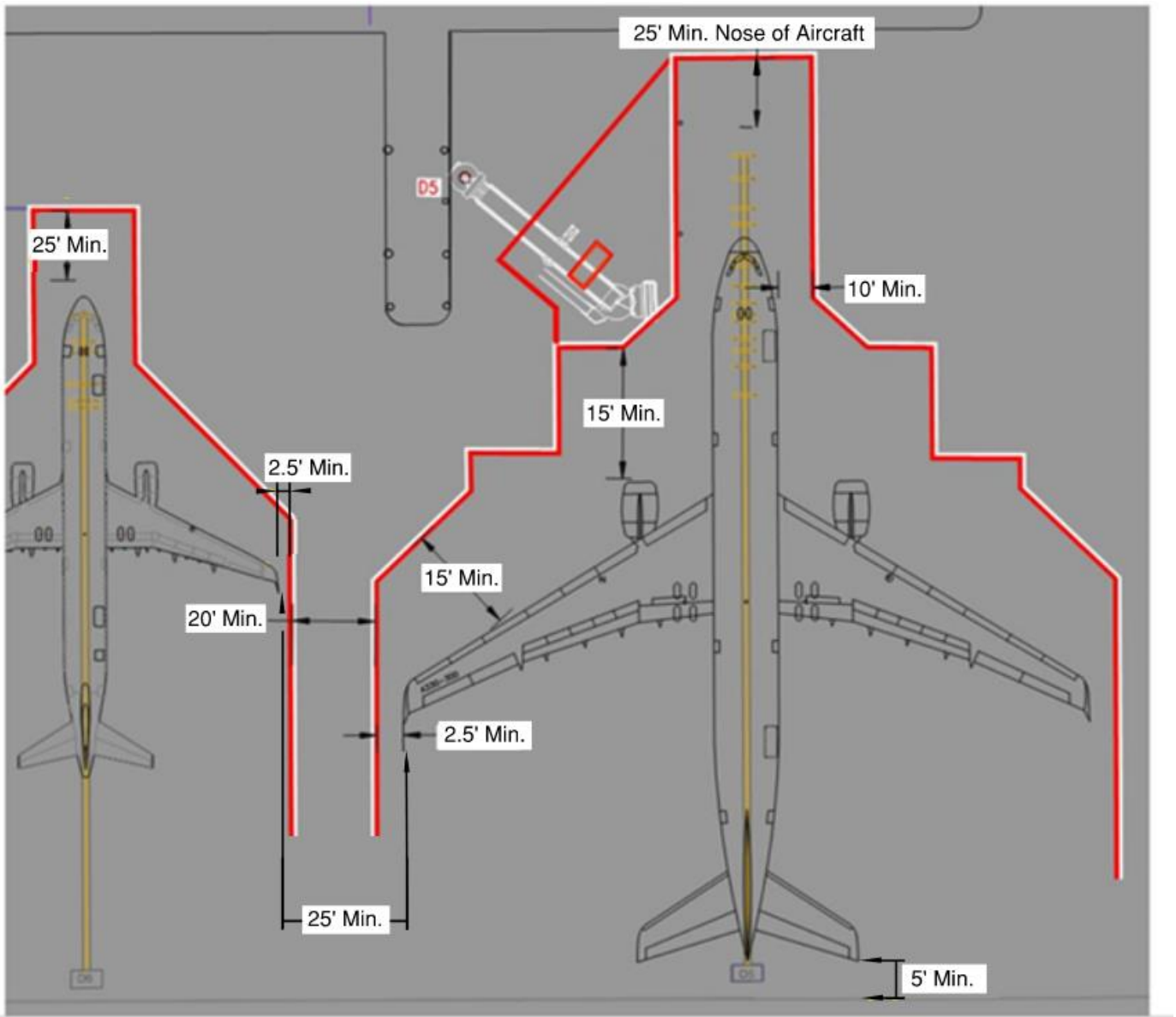


Figure 1
NTS

1.2.3. Fuel Pit Location

- Shall not be located in the following areas:
 - Under aircraft engines or designated engine hot zones.
 - Under landing gear and fuselages.
 - Any area that is required for aircraft servicing of cargo door area.
 - Any area that would impede aircraft servicing ports.
 - Outside the OSZ or within the passenger boarding bridge (PBB) movement area.
 - Any areas that require fueling vehicles to back into position to connect to the aircraft.

1.2.4. PBB/STOW Position

- To be coordinated and approved by the HAS project manager.
- Design should consider the following at a minimum; aircraft door positioning/servicing requirements, extension/retraction/rotation requirements, location of necessary equipment, and consideration to GSE.

1.2.5. Belt Loader Location

- To be coordinated and approved by the HAS project manager.
- Shall be located outside the OSZ.
- Clearance must be adequate to allow for GSE to operate in a manner that does not impede any part of the VSR.

1.3. Striping Standards

1.3.1. Operational Safety Zones

- The pavement marking for an OSZ shall consist of the following:
 - Two adjacent markings that are white and red.
 - Solid red marking that is 6 inches in width on the interior portion of the OSZ (aircraft side).
 - Solid white marking that is 6 inches in width on the outer portion of the OSZ (non-aircraft side).
- The markings shall extend to the adjacent VSR or to the tail limit of the design aircraft.
- If an alternate marking is required it shall consist of dashed white and red lines as described above. The length of each dash and space shall be 8 feet in length respectively.

1.3.2. Lead-in Lines

- The center lead-in line shall be a solid 1-foot yellow marking with 4-inch wide black enhancement.
- If an alternate lead-in line is required it shall consist of dashed yellow and black enhancement as described above. The length of each dash and space shall be 4 feet in length respectively.
- The lead-in line shall extend a minimum of 20 feet past the last stop bar location or tie directly into any adjacent VSR edge marking.
- The lead-in line lengths shall be submitted to the HAS project manager and HAS operations for approval.

1.3.3. Gate Designators

- The gate designator lettering shall be 6' black lettering on a yellow background. The yellow background should provide a 6" border for the black lettering.
- The gate designator shall not be marked within VSR.
- Provide 2 feet min clearance between VSR edge marking and edge of gate designator.

1.3.4. Stop Bar Markings

- The stop bar marking shall be perpendicular to the lead-in line (see **Figure 2**).

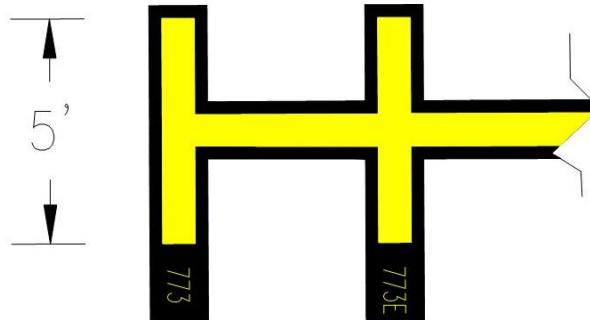


Figure 2

NTS

- The stop bar marking shall be 1-foot in width and 5-feet in length. They are to consist of a 1-foot yellow marking with a 4-inch black enhancement.

1.3.5. Aircraft Designator Markings

- Aircraft designator markings of 1-foot tall yellow lettering on a black background including a 4-inch black enhancement.
- Multiple aircraft stencils on a single stop bar are separated by 1 letter spacing.
- Single aircraft designations follow the latest FAA Order 7360.1 for aircraft type designation. Example: 762 for the Boeing 767-200.
- Multiple aircraft type designations on a single stop bar state aircraft model and consolidate types with a "/". Example: 767-2/3 for the Boeing 767-200 and 767-300.

1.3.6. Passenger Walkway Marking Area

- The minimum width for a passenger walkway shall be 5-feet.
- The area shall be delineated with a solid 6-inch white outer marking. In addition, the enclosed area shall be hatched with solid 6-inch white lines spaced at 6-feet intervals.

1.3.7. Passenger Boarding Bridge Movement Area

- The pavement marking shall consist of interior 6-inch red and outer 6-inch solid white line. In addition, the area shall be hatched with solid 6-inch red lines spaced at 6 feet intervals.
- The stow box (9'x9') marking shall be 1-foot wide red marking (see **Figure 3**) and parallel/perpendicular with the lead-in line.

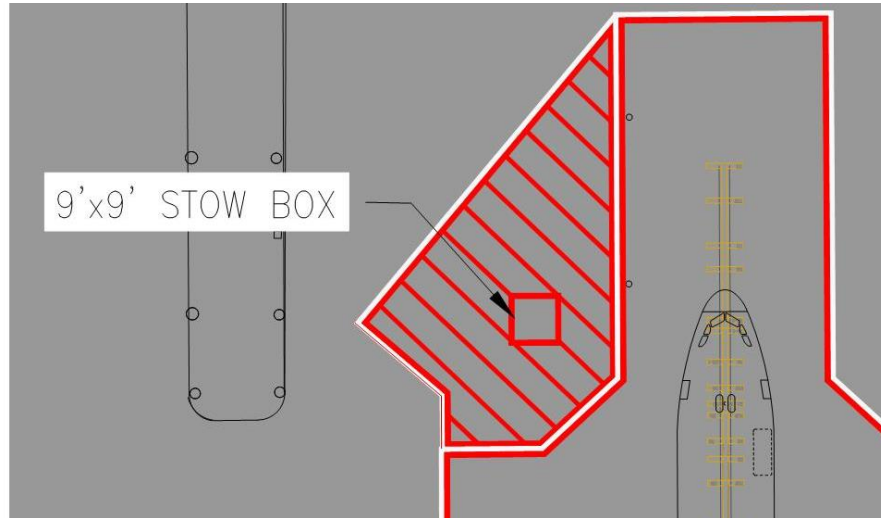


Figure 3

NTS

1.4. Paint Standards

1.4.1. For approved color standards, use of reflective media, and surface application reference the appropriate and most up to date FAA Advisory Circular including but not limited to:

- AC 150/5340-1 – Standards for Airport Markings.
- AC 150/5370-10 – Standard Specifications for Construction of Airports.

48- MODULAR RESTROOMS DESIGN GUIDELINES



Houston Airport System Modular Restroom Guidelines


February 7, 2020




George Bush Intercontinental Airport
2800 North Terminal Road
Houston, TX 77032

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 2.14.20
Name: Mario Diaz
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Position: Chief Development Officer
Department: Houston Airport System

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Modular Restroom Guidelines

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Section 1.1 Overview

This manual establishes specific design criteria for all restrooms located in terminal buildings operated or maintained by the Houston Airport System (HAS). It serves as a guide for restroom new construction and remodel work at George Bush Intercontinental Airport (IAH), William P. Hobby Airport (HOU) and Ellington Field Airport (EFD), hereinafter referred to as "Airport". This design criteria manual is not intended to limit or dismiss the talents of the Designer nor knowledge of the Contractor, but set baseline criteria for the design intent, finish material palette and fixture selections for future restroom designs at the Airport.

Section 1.2 Introduction

This Modular Restroom Guidelines assessed the existing standards for accessibility, maintenance, durability, ease of flow and functionality and provides design guidelines that meet or exceed each of these criteria relating to architectural and engineering design in compliance with the Airport's additional design criteria and manuals, local building codes and jurisdiction, and state and federal accessibility mandates. The Guidelines provide the selection of new architectural fixtures, finishes, lighting, & accessories and mechanical systems performance.

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Section 1.3 Design Concept

The new design concept answers human behaviors by using the open island concept. Customers can more easily see what stalls are available upon entry of the room, minimizing wait times. The Baby Care Station and Medical Alcoves add extra privacy for those personal activities. The open layout includes perimeter banks of toilet fixtures, glass privacy screens and toilet partitions encompassing a central island for hand washing and drying. This concept minimizes the use of paper products, reduces standing floor water, and facilitates ease of traffic flow. Metal ceilings, motion detection plumbing fixtures and LED lighting throughout maximize minimal maintenance, durability, and energy savings. Ease of surface cleaning is answered with no wall grout joints, contiguous counter/sinks and large format wall panels. Design elements relate between the wall pattern and textures.

Section 1.4 Procedures for Changes to this Manual

The goal of this Guideline is to maintain existing information and provide an efficient framework for incorporating newer design criteria in the future. The Asset Engineering Department within the HAS Infrastructure Division will be responsible for evaluating and recommending approval to the Change Review Committee (CRC) through a Change Management Approval Process (CMA). Change will be implemented by variance or change requests. Variance requests address a project-specific change while Change Requests address permanent revisions to the Standards. For variance requests, the Project Manager is responsible for submitting a Variance/Change Request Form including all supporting documentation for consideration of the proposed variance. For change requests, the Asset Engineer is responsible for submitting a Variance/Change Request Form including all supporting documentation for consideration of the proposed change.

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Section 2.1 General Requirements

The effective contract Notice to Proceed date for design services of new and/or remodeled Airport restroom will determine the applicable edition of a code, regulation, standard, amendment, and/or addendum for use on a project. The most updated version is applicable.

a. Current Applicable Codes and Guidelines:

- i. Houston Airport System Design Manual
- ii. International Building Code, (IBC) 2012 edition as amended by the City of Houston
- iii. Uniform Mechanical Code, (UMC) 2012 edition as amended by the City of Houston
- iv. Latest edition of SMACNA HVAC Duct Construction Standards
- v. Uniform Plumbing Code, (UPC) 2012 edition as amended by the City of Houston
- vi. National Electrical Code, (NEC) 2014 edition
- vii. International Energy Conservation Code, (IECC) 2015 edition as amended by the City of Houston
- viii. International Fire Code, (IFC) 2012 edition
- ix. ASHRAE 90.1, 2013 edition as amended by the City of Houston
- x. ASHRAE 62.1, 2013 edition as amended by the City of Houston
- xi. National Sanitation Foundation / American National Standards Institute, (NSF/ANSI) 61
- xii. Americans with Disabilities Act, (ADA) 2010
- xiii. Texas Accessibility Standards, (TAS) 2012

b. Design Criteria:

- i. Occupancy Type (304): B, Business
- ii. Occupancy Category (T1604.5): II
- iii. Construction Type (602): IA
- iv. Plumbing Fixtures per Chapter 2901.1, IBC 2012
- v. Fire Protection:
 1. Portable Fire Extinguishers, Class A, 75 feet maximum travel distance
- vi. Interior Finishes (803.9): B & C

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Section 2.2 Accessibility Requirements

1. Use GFI outlets and provide a minimum of 15" mounting height where necessary according to accessibility requirements.
2. Alarms- alarms & strobes & ARA communication devices must be installed according to accessibility requirements.
3. Field verify all appliance dimension before construction.
4. Provide minimum of 27" high x 30" wide x 11" deep clear knee space conforming with accessibility requirements.
5. Faucet sets to conform with accessibility requirements.
6. 34" Max. Height to top of sink or counter per accessibility requirements.
7. Sink Max. - depth = 6"
8. Provide protective covering over exposed pipes & surfaces accessibility standard (Typ.)
9. Flush control on open side of W.C.
10. Door signs shall use the international symbol of accessibility and shall be mounted on latch side wall at 60" A.F.F. on the centerline of the sign.
11. Restroom accessible signage shall comply with HAS Signage and Wayfinding Standards.
12. Building entry - Max. slope of 1:20 and a Max. cross slope of 1:48.
13. All door controls area to be "lever" handle type conforming to accessibility standards.
14. Provide door stops and silencers at all doors, typ.
15. Architect / Designer shall provide 18" Min., (24" preferred) clear at pull side of doors in order to conform to accessibility standards.
16. Door closers- the sweep period of the closer shall be adjusted so that from an open position of 90°, the time required to move the door to a position of 12° from the latch is 5 seconds. Measured to the leading edge of the door.
17. Interior hinged, sliding, and folding doors shall have a 5 pound opening force.
18. Verify keying requirements with owner.
19. Accessible thresholds to be Max. 1/2" high.



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Section 2.2 Accessibility Requirements (continued)

20. Accessible urinal to be 17" high with 14" tapered elongated trim with flush controls at 44" A.F.F. Max.
21. Accessible water closet to be 17" to 19" A.F.F. measured to the top of the toilet seat.
22. Required accessible elements shall be identified per HAS Signage and Wayfinding Standards.

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Section 2.3 Architectural Requirements

- a. General Features:
 - i. Floors: Porcelain tile
 - ii. Walls: High-pressure compact laminated panels (painted gypsum board if required)
 - iii. Base: Porcelain tile
 - iv. Ceilings: Perforated metal panels (painted gypsum board if required)
 - v. Toilet Partitions: Tempered laminated glass panels with high-pressure laminated dividers. All typical toilet compartment doors shall be of equal dimension. Coordinate with HAS for number of toilet compartment doors for attic stock. All typical wheelchair accessible and ambulatory accessible toilet compartment doors shall be of equal dimension. Coordinate with HAS for number of wheelchair accessible and ambulatory accessible toilet compartment doors for attic stock.
 - vi. Lavatory: Solid Surface counter with one-piece solid surface sink and integral trough
 - vii. Overhead Signage: See Signage and Wayfinding Standards
 - viii. Marquee mirror: Stainless steel beveled edge with LED back lit perimeter edges
 - ix. Misc. Millwork: Solid surface countertops

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Section 2.4 Finish Requirements

Interior finishes shall comply with Class B and C as defined in Section 803.9 of the IBC.

- a. Flooring: Large format Porcelain tile floors in field and accent colors, shall be installed in accordance to the floor patterns shown in current Guidelines. Porcelain tile floors shall also comply with the HAS Design Standards.
- b. Base: 12" high Porcelain tile wall base shall be installed in accordance to current Guidelines and shall also comply with the HAS Design Standards.
- c. Walls: All walls shall be of non-porous large format Trespa wall panels. Pattern to match Wall Finish Elevation provided in current Guidelines or an approved alternative. Walls shall also comply with the HAS Design Standards.
- d. Ceilings: Ceilings shall be composed of perforated metal panels, hard surface ceilings, accessible acoustical lay-in tiles, and coves as detailed in current Guidelines. Ceilings shall also comply with the HAS Design Standards.
- e. Signage: Wayfinding signage shall express the gender of each restroom as detailed in current Guidelines and shall also comply with Signage and Wayfinding Standards.
- f. Accessories: Accessories for kid care, feminine hygiene, personal hygiene and accessibility access shall be provided per current Guidelines and shall also comply with the HAS Design Standards.
- g. Electrical Receptacles: to be Lutron Claro or approved equal. Manufacturer to submit full line of colors. Match adjacent tile wall finish.

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Section 2.5 Mechanical Requirements

All new and remodeled restrooms shall be designed with sufficient conditioned and heated air, shall conform to basic operating parameters of the systems currently in operation and shall adhere to the HAS Design Standards.

- a. Design Conditions
 - i. Heating: winter inside comfort design - 72 degrees F, DB
 - ii. Cooling: summer inside comfort design - 75 degrees F, DB
 - iii. Relative Humidity - 50%
 - iv. Outside Design Temperatures -
 - 1. Summer 98 degrees F DB, 80 degrees F WB
 - 2. Winter 20 degrees F BD
 - v. Energy Conservation: All newly constructed and remodeled restrooms shall meet the energy performance standards set forth by the Houston Commercial Energy Conservation Code.
- b. Piping: Piping shall meet the corrosion prevention requirements if underground and shall comply with the HAS Design Standards.
- c. Pumps: Pumps, including chilled and hot water pumps, shall comply with the HAS Design Standards.
- d. Air Handling Units: Packaged and built-up units shall comply with the HAS Design Standards.
- e. Water to Water Hot Water Generators: Space heating where provided for by Water to Water Hot water systems shall comply with the HAS Design Standards.
- f. Ductwork: All new and altered ductwork shall be constructed and installed in accordance with SMACNA and ASHRAE guidelines, and shall comply with the HAS Design Standards
- g. Pipe Insulation: All insulations, jackets, adhesives, coatings, vapor barrier mastics, etc. shall meet the requirements of NFPA 90-A, ASTM E84 and shall comply with the HAS Design Standards.
- h. Insulation: Insulation for pumps and ductwork shall comply with the HAS Design Standards.
- i. Air Devices and Boxes: Shall comply with the HAS

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Section 2.5 Mechanical Requirements (continued)

- Design Standards.
- j. Controls: Shall comply with the HAS Design Standards
 - k. Vibration Isolation: Proper vibration isolation shall be provided to prevent excessive noise or transmission of vibrations to the building structure. Vibration isolation shall conform to the latest ASHRAE Guidelines, NFPA 90-A and shall comply with the HAS Design Standards.
 - l. Noise Control: Noise producing mechanical equipment shall be designed so as not to exceed acceptable levels as set forth by industry standards and shall comply with the HAS Design Standards.
 - m. Exhaust System: New and remodeled exhaust systems shall provide a minimum of 30% more exhaust than the requirements listed in ASHRAE 62.1-2013 or 20 Air Changes per hour whichever is higher.
 - n. Typical exhaust products
 - i. Wall mounted exhaust fans
 Manufacturer: Greenheck
 Model: CWB
 Description: Wall mounted centrifugal
 - ii. Roof-mounted exhaust fans
 Manufacturer: Greenheck
 Model: GB
 Description: Roof mounted downblast centrifugal
 - iii. Inline exhaust fans
 Manufacturer: Greenheck
 Model: BSQ
 Description: Inline centrifugal

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Section 2.6 Electrical Requirements

Lighting

1. Provide LED light fixtures with associated drivers for all public spaces. Refer to section 4.2 for approved public area lighting fixture selections.
2. Provide 20 foot-candles 30" above floor.
3. Lighting power density shall not exceed 1 watt per square foot.
4. Provide ceiling mounted occupancy controls.
5. Provide adequate light fixtures connected to generator or battery power to allow egress from the space and to allow minimal usage of the room.
6. Provide fluorescent strip fixtures in all walk-in plumbing chases with manual switch control.
7. Lighting shall comply with the HAS Design Standards.
8. Lighting selection based upon current City of Houston code. Revisions may be required if new codes are adopted with more stringent standards.
9. All lamps to be 4000K unless otherwise noted.
10. Provide adequate lighting to prevent shadowing.

Power

1. Provide hard wired power for automatic flush valves, faucets, and foaming soap.
2. Provide power for selected hand drying fixture.
3. Provide two GFCI receptacles above counter for convenience use.
4. Provide at least one GFCI receptacle in each walk-in plumbing chase.
5. Provide visual or audible/visual fire alarm notification devices in each restroom.
6. All new and remodeled electrical and communications work shall comply with the HAS Design Standards.

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Section 2.7 Plumbing Requirements

1. All chases shall be full walk-in chases with minimum 24" clear between carriers. This scenario allows use of flushing fixtures PK-1 and PW-1 in the public restrooms. Where possible plumbing chases shall include waterproofing including floor and 12" up walls and shall include floor drains.
2. If a full walk-in chase is not feasible for all public restroom walls then use alternate flushing fixtures PK-2 and PW-2.
3. Water closets shall be white vitreous china wall hung water closets with concealed flush valves. Flush valves shall be hard wired powered infrared sensing type.
4. Urinals shall be white vitreous china wall hung urinals. Flush valves shall be hard wired powered infrared sensing type.
5. Public restroom lavatories shall be two station trough type lavatory system with infrared faucets.
6. Family restroom lavatories shall be wall mounted white vitreous china with infrared faucets.
7. Faucets shall be AC powered.
8. Lavatories shall be provided with undercounter point of use mixing valves to provide tempered water to public fixtures per code.
9. All exposed tailpieces, stop valves, supply risers, etc under the counters shall be provided with insulated ADA covers.
10. All domestic water piping in chases shall be minimum Type 'L' copper with wrought copper soldered fittings. Water hammer arrestors shall be provided in each chase per the manufacturer's recommendations.
11. All sanitary piping above slab shall be no-hub service weight cast iron with heavy duty wide band couplings.
12. All sanitary vent piping shall be no-hub service weight cast iron with standard duty couplings.
13. All new and remodeled plumbing work shall comply with the HAS Design Standards.
14. Plumbing fixtures shall comply with the HAS

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Section 2.7 Plumbing Requirements (continued)

Design Standards.

15. Wall cleanouts shall be provided to furthest extent possible. Wall cleanouts shall have round chrome plated covers to be painted to match adjacent wall finish. Floor cleanouts shall be provided every 75 ft. and as required by code.
16. Floor drains in restrooms and Janitor's room shall be coated cast iron body with square strainer.
17. At Sink Island where wall chase is not full height and thus will not allow for walk-in, thickness of the wall shall allow a clearance of 3 to 4 inches between metal studs to allow for passing of insulated pipes.

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Section 3.1 General Design Requirements

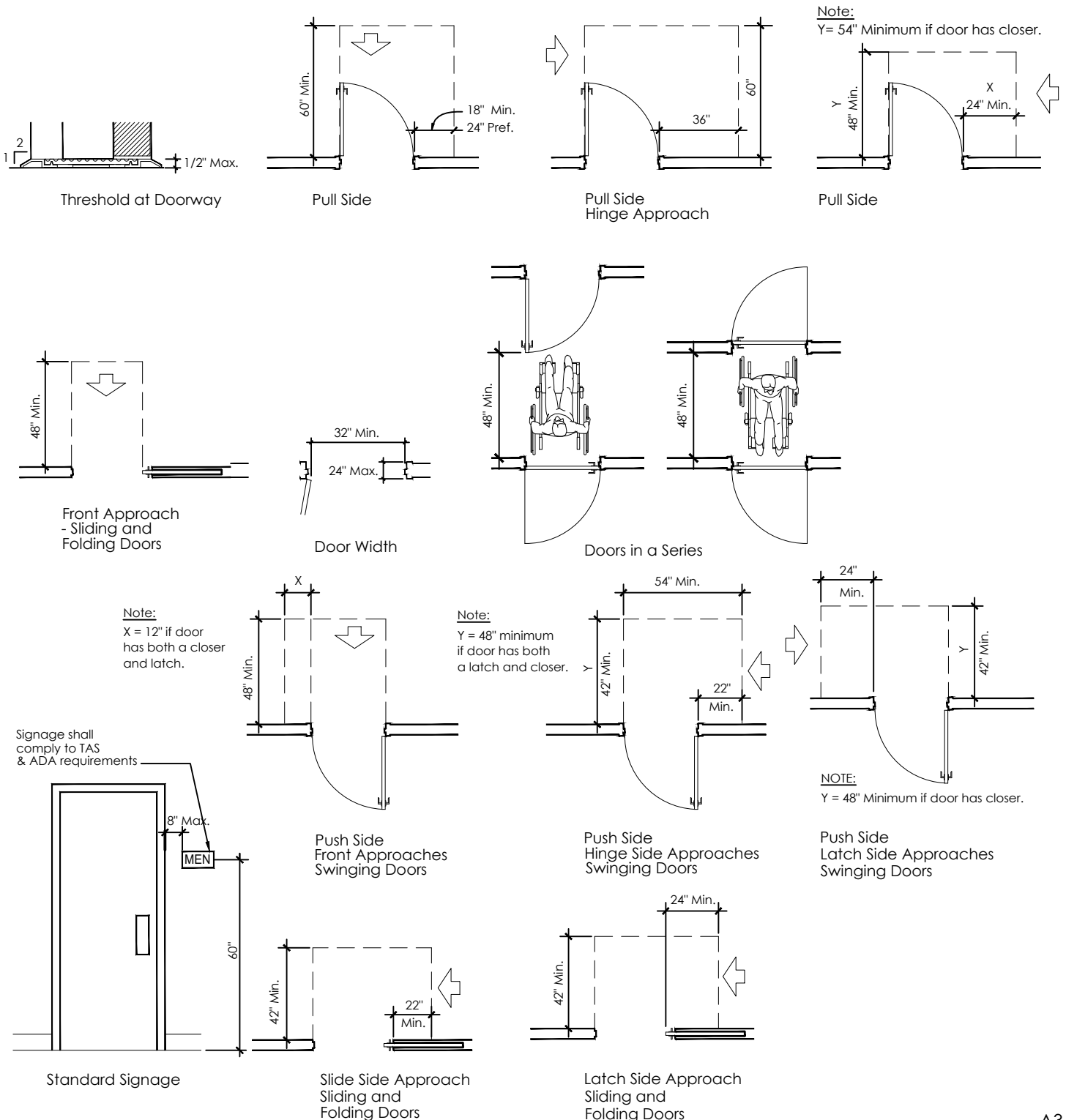
- A1 Sheet Index
- A2 ADA Standards
- A3 ADA Standards
- A4 ADA Standards
- A5 ADA Standards
- A6 Typical Sink Island Floor Plan
- A7 Typical ADA Toilet Stalls Floor Plan
- A8 Typical Toilet Stalls Floor Plan
- A9 Specialty Areas Floor Plan and Elevation
- A10 Specialty Areas Floor Plan and Elevation
- A11 Family Restroom and Janitor Room Floor Plan
- A12 Family Room Elevation
- A13 Family Room Elevation
- A14 Family Room Elevation
- A15 Janitor Room Elevation
- A16 Typical Restroom Floor Finish Plan
- A17 Typical Restroom Reflected Ceiling Plan
- A18 Typical Wall Finish Elevation
- A19 Typical Toilet Stalls Elevation
- A20 Typical Sink Island Elevation
- A21 Typical Sink Island Cross-Section
- A22 Sidelit Mirror Elevation and Sectional Plan

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Door Clearances

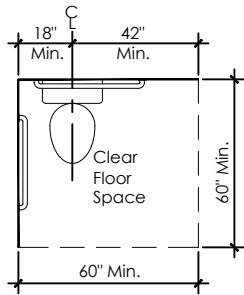


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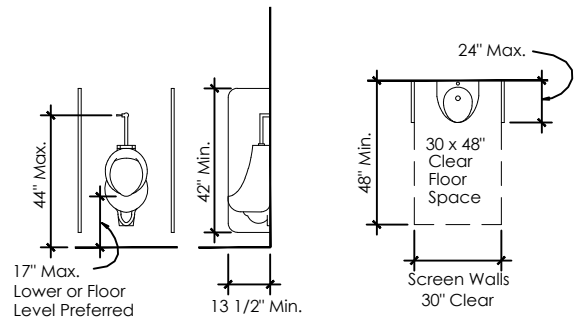
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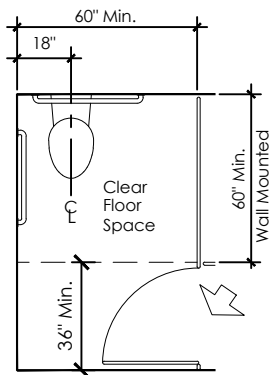
Bathroom Fixtures, Lavatory, and Sink Clearances



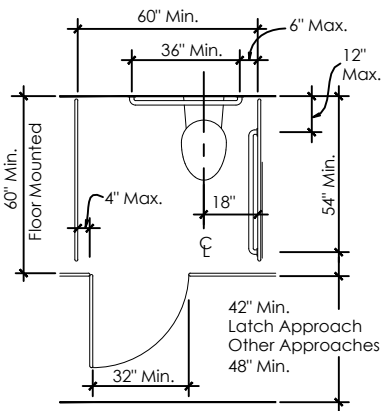
Clear Floor Space at Water Closets



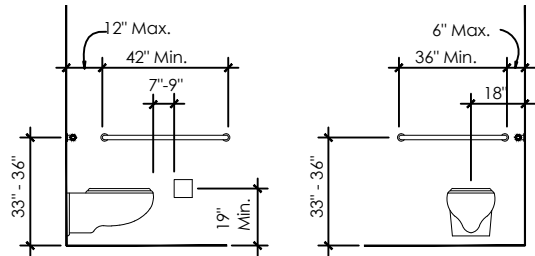
Urinal Heights



End-of-Row Stall

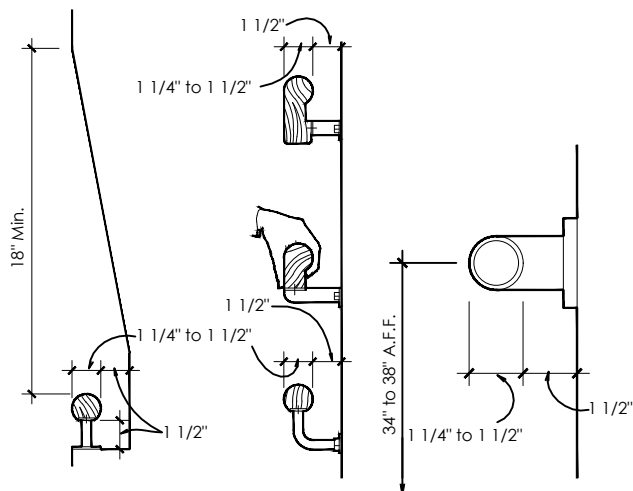


Standard Stall

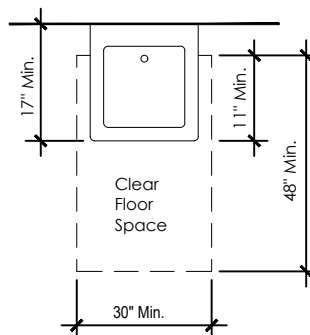


Grab Bars at Water Closet

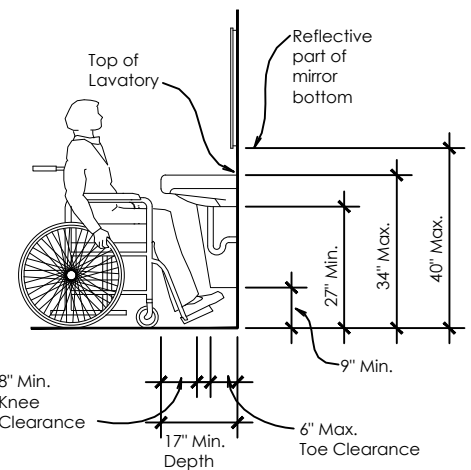
Toilet Fixtures



Handrail/Grab Bar Spacing



Lavatory Clearances

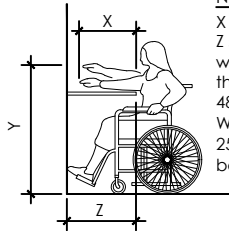
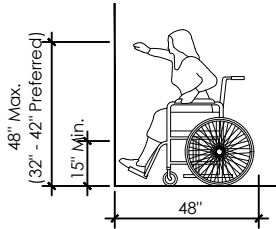


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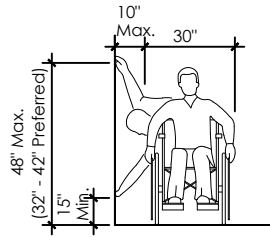
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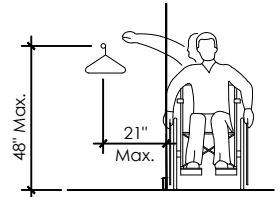
Reach Ranges



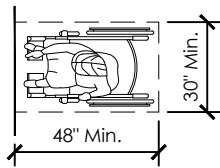
NOTE:
 X shall be $\leq 25"$
 Z shall be $\geq X$,
 when $X < 20"$,
 then Y shall be
 48" maximum.
 When X is 20" to
 25", then Y shall
 be 44" maximum.



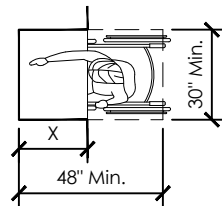
Unobstructed Side Reach



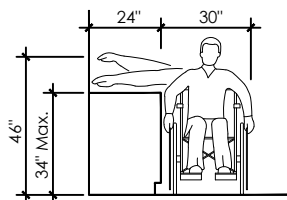
Closet



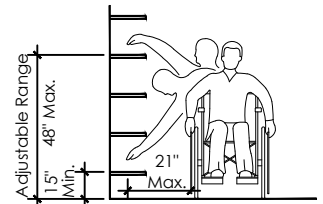
Unobstructed Forward Reach



Maximum Forward Reach Over an Obstruction



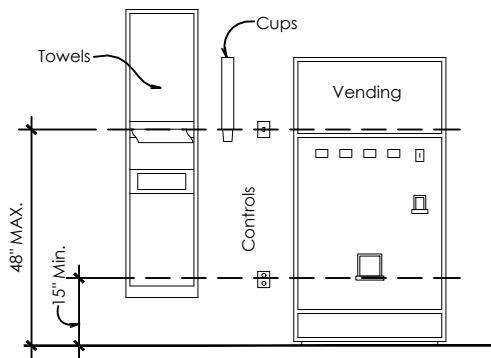
Max. Side Reach Over Obstruction



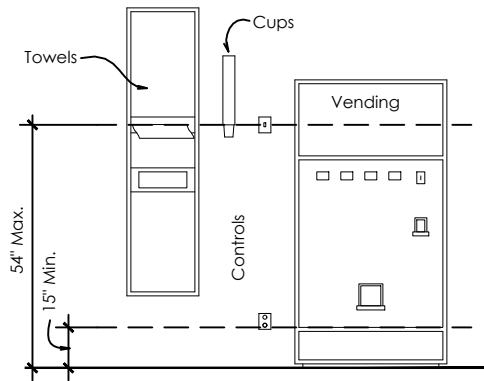
Shelves

Forward Reach

Side Reach



Forward Reach Possible



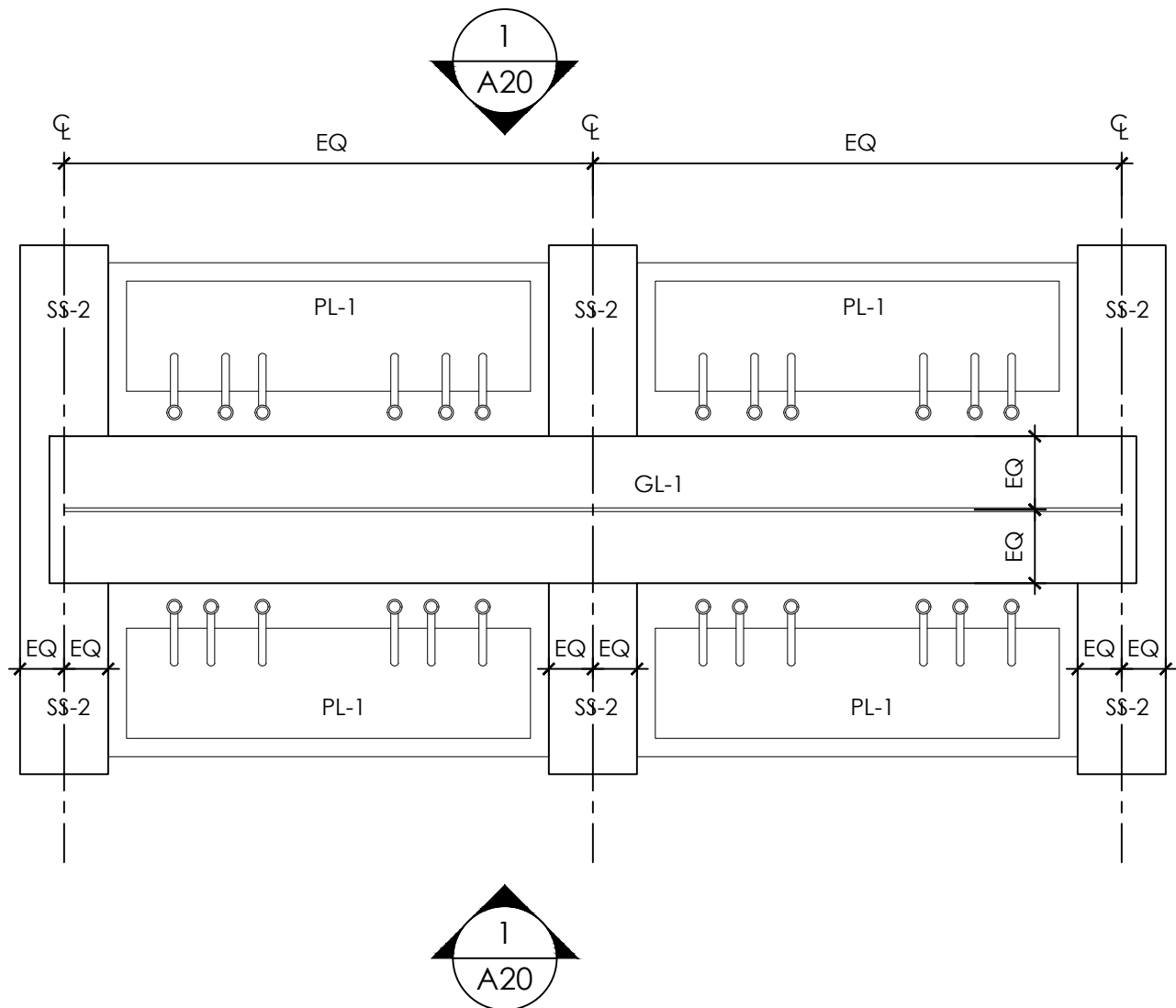
Side Reach Possible

Control Reach Limits

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1. Typical Sink Island Floorplan

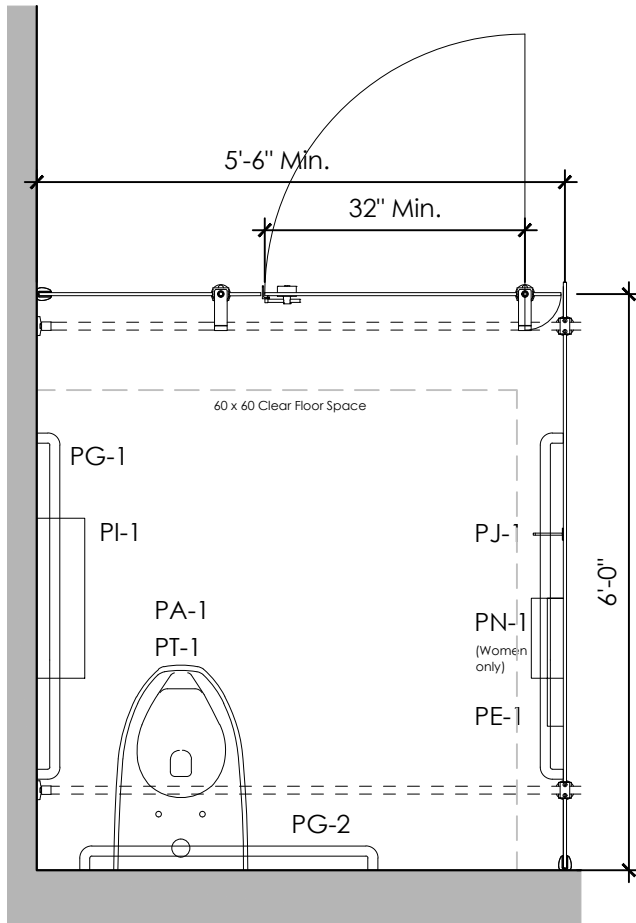
Scale: 1/2"=1'-0"

The Sink Island in the Men's and Women's Restroom is identical in size, dimension, and type of equipment installed.

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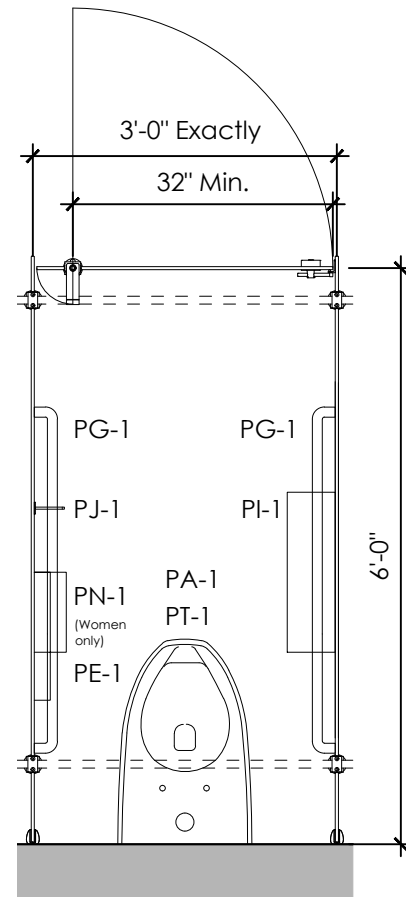
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1. Typ. Wheelchair Accessible Toilet Compartment

Scale: 1/2"=1'-0"

Each Men's and Women's Restroom shall have at least one Wheelchair Accessible Toilet Stall. Reference TAS guidelines for spacing and mounting height requirements.



2. Typ. Ambulatory Accessible Toilet Compartment

Scale: 1/2"=1'-0"

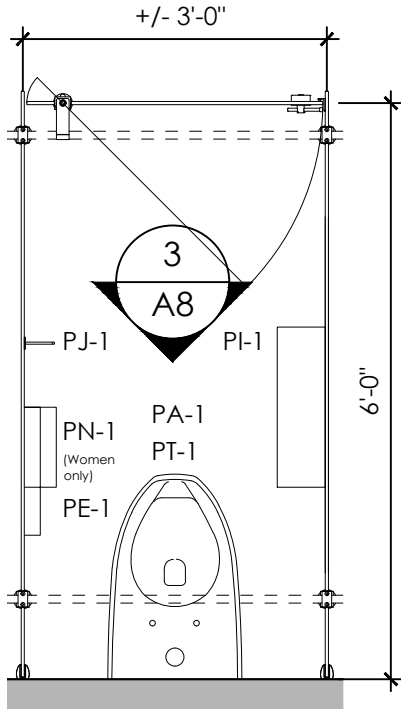
Each Men's and Women's Restroom shall have at least one Ambulatory Accessible Toilet Stall. Reference TAS guidelines for spacing and mounting height requirements.

Note: All typical wheelchair accessible and ambulatory accessible toilet compartment doors shall be of equal dimension. Coordinate with HAS for number of wheelchair accessible and ambulatory accessible toilet compartment doors for attic stock.

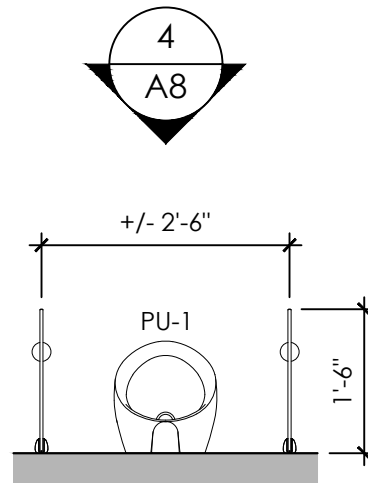
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Note: All typical toilet compartment doors shall be of equal dimension. Coordinate with HAS for number of toilet compartment doors for attic stock.

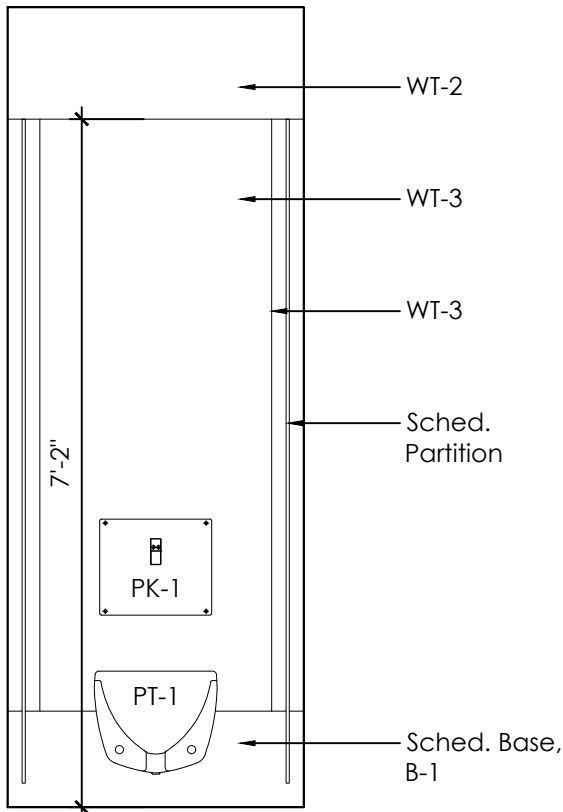


1. Typ. Toilet Stall

Scale: 1/2"=1'-0"

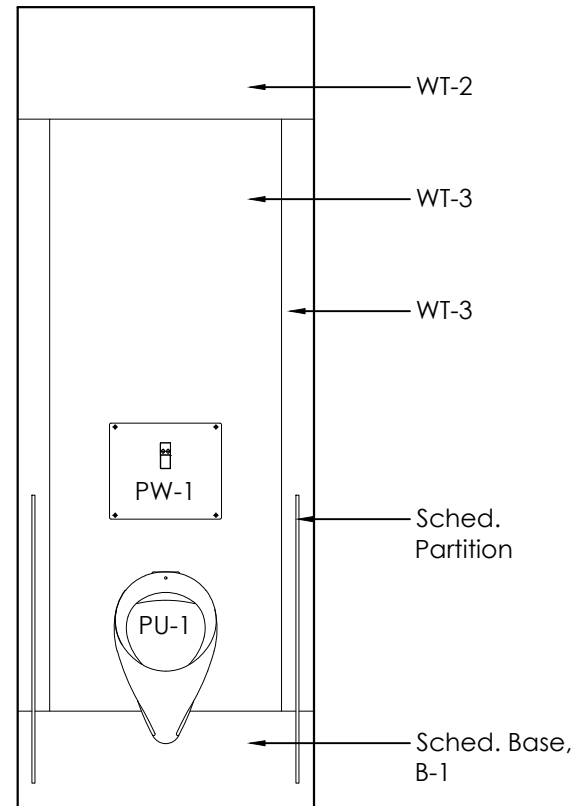
2. Typ. Urinal

Scale: 1/2"=1'-0"



3. Typ. Toilet Stall Elevation

Scale: 1/2"=1'-0"



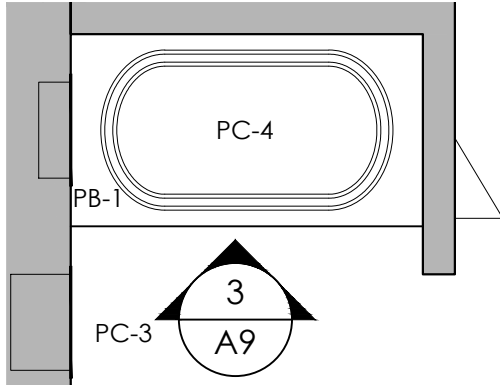
4. Typ. Urinal Elevation

Scale: 1/2"=1'-0"

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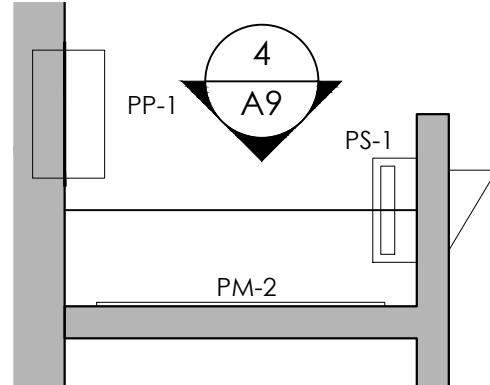
Issued: February 7, 2020



1. Typ. Baby Changing Area Plan

Scale: 1/2"=1'-0"

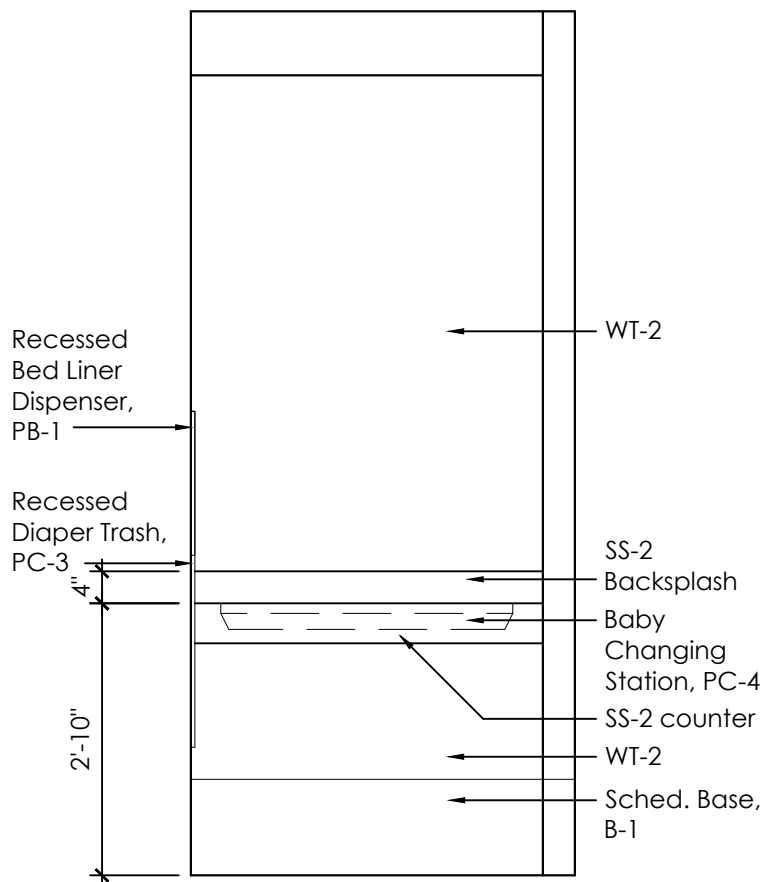
Each Men's and Women's Restrooms shall have one baby changing station as shown in this example.



2. Typ. Bio Med Niche Plan

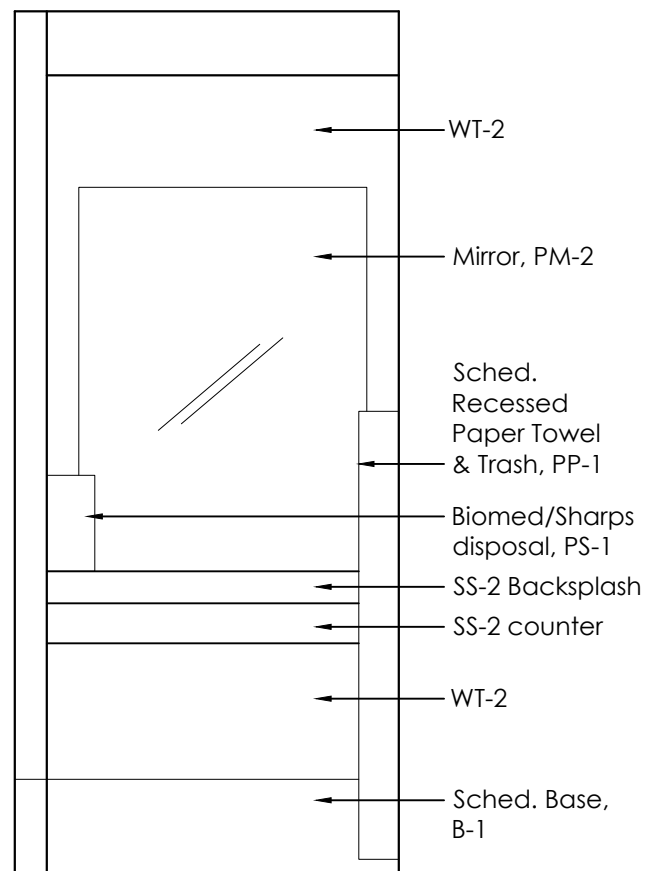
Scale: 1/2"=1'-0"

Each Men's and Women's Restrooms shall have one health area as shown in this example.



3. Typ. Baby Changing Area Elevation

Scale: 1/2"=1'-0"

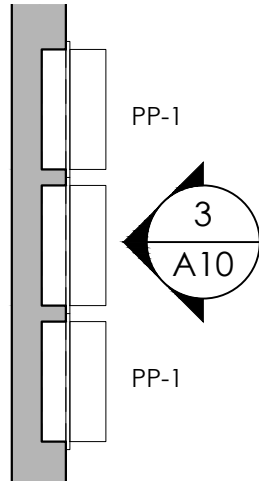


4. Typ. Bio Med Niche Elevation

Scale: 1/2"=1'-0"

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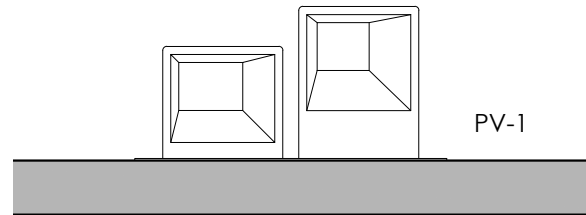
Modular Restroom Guidelines
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1. Typ. Sanitation Station Plan

Scale: 1/2"=1'-0"

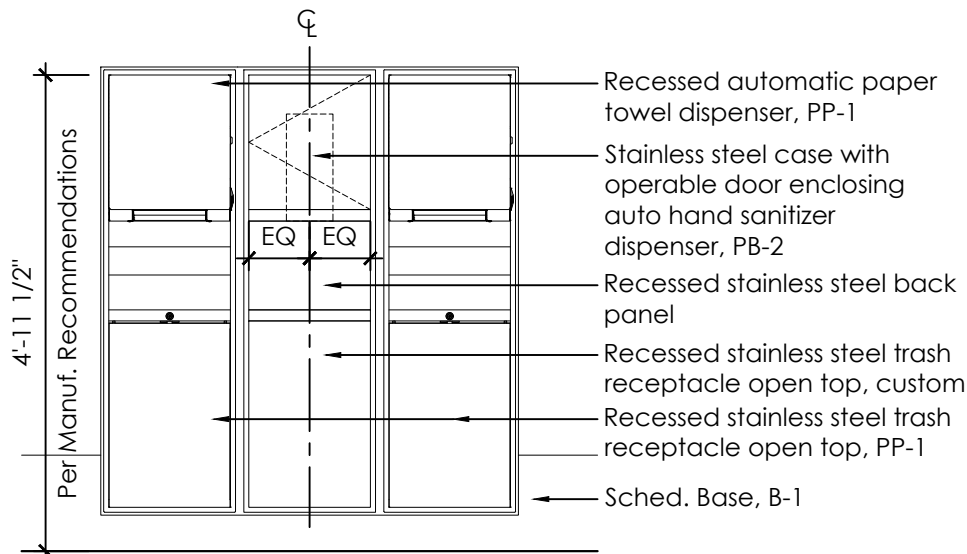
Each Men's and Women's Restrooms shall have an area setup near the lavatory that is equipped with paper towels, hand sanitizer, and a trash can.



2. Water Bottle Refill Station

Scale: 1/2"=1'-0"

At the entry to the restrooms where the existing water fountains are (if any) there will be a water bottle refill station. Reference Plumbing Fixture Specifications for PV-1. The type of installation will vary per field condition, recessed is the preferred option.



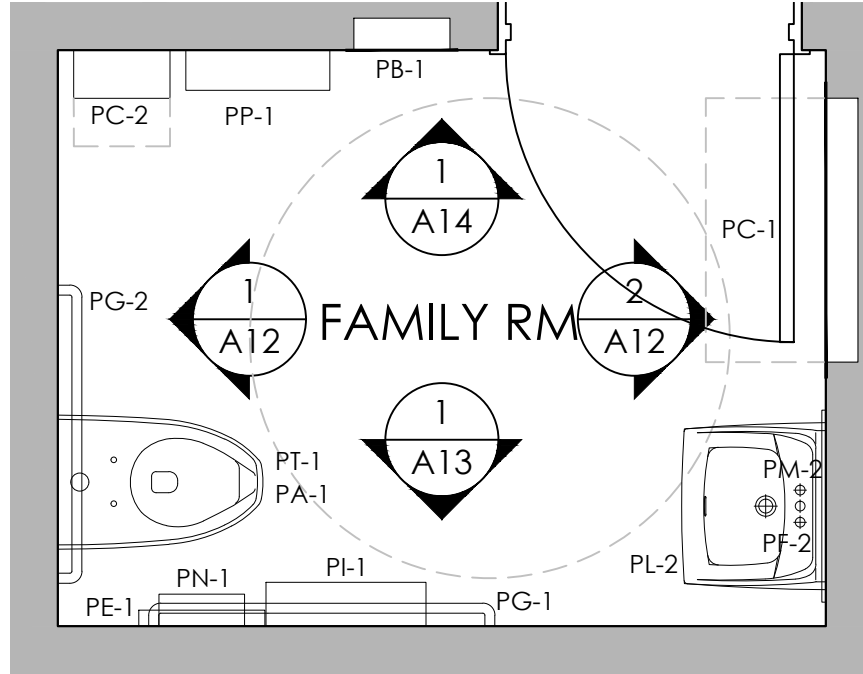
3. Typ. Sanitation Station Elevation

Scale: 1/2"=1'-0"

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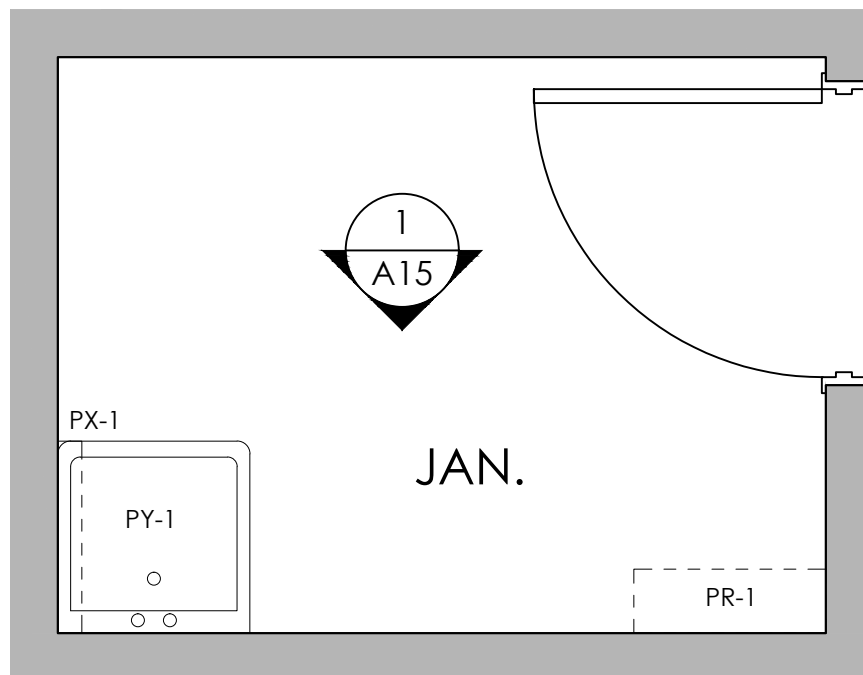
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1. Typical Family Restroom Floorplan

Scale: 1/2"=1'-0"

For each set of Men's and Women's restrooms, there shall be a Family Restroom provided to serve as a unisex restroom. Reference TAS guidelines for spacing and mounting requirements of fixtures.



2. Typical Janitor Room Floorplan

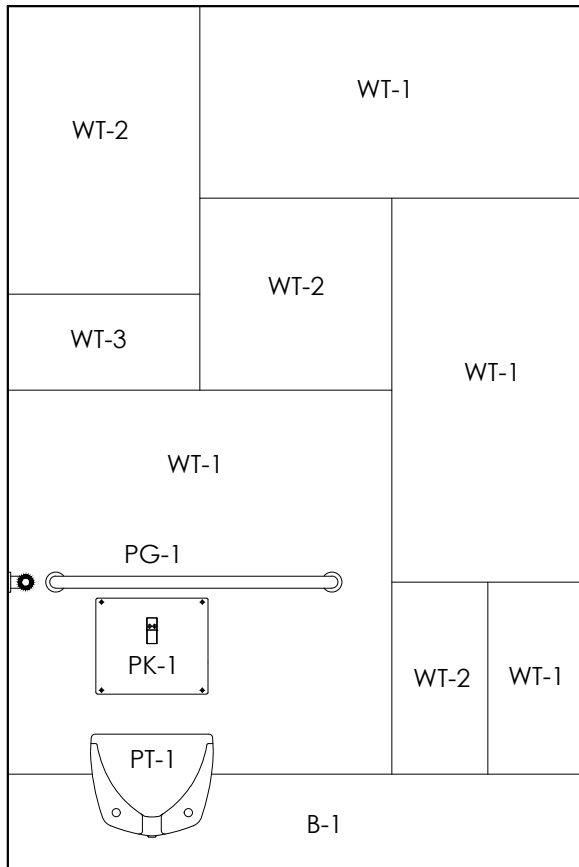
Scale: 1/2"=1'-0"

For each set of Men's and Women's restrooms there should be one Janitor room equipped with a service sink. Room size should allow for a 5ft un-obstructed turning radius. Reference TAS guidelines for spacing and mounting requirements of fixtures.

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Modular Restroom Guidelines

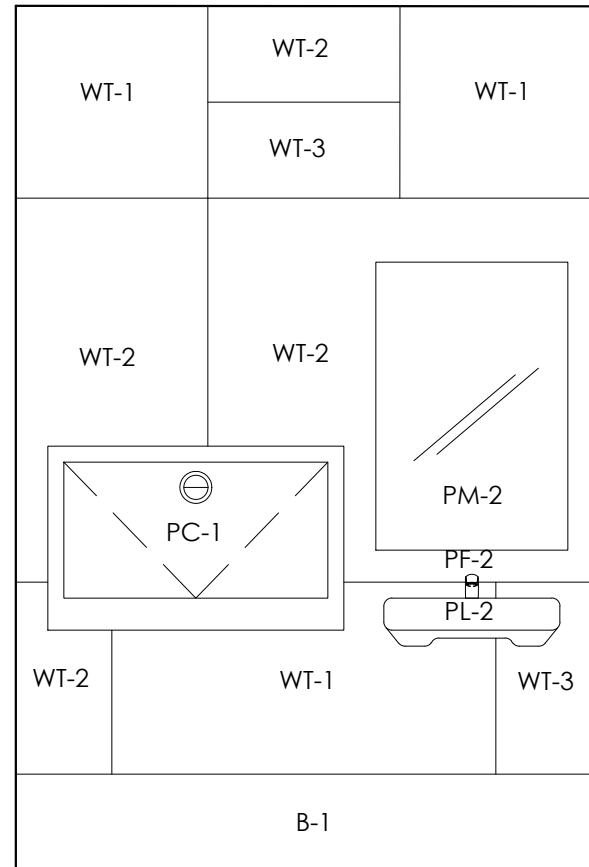
Issued: February 7, 2020



1. Family Room Elevation at Toilet

Scale: 1/2"=1'-0"

Reference TAS guidelines for spacing and mounting height requirements.



2. Family Room Elevation at Sink

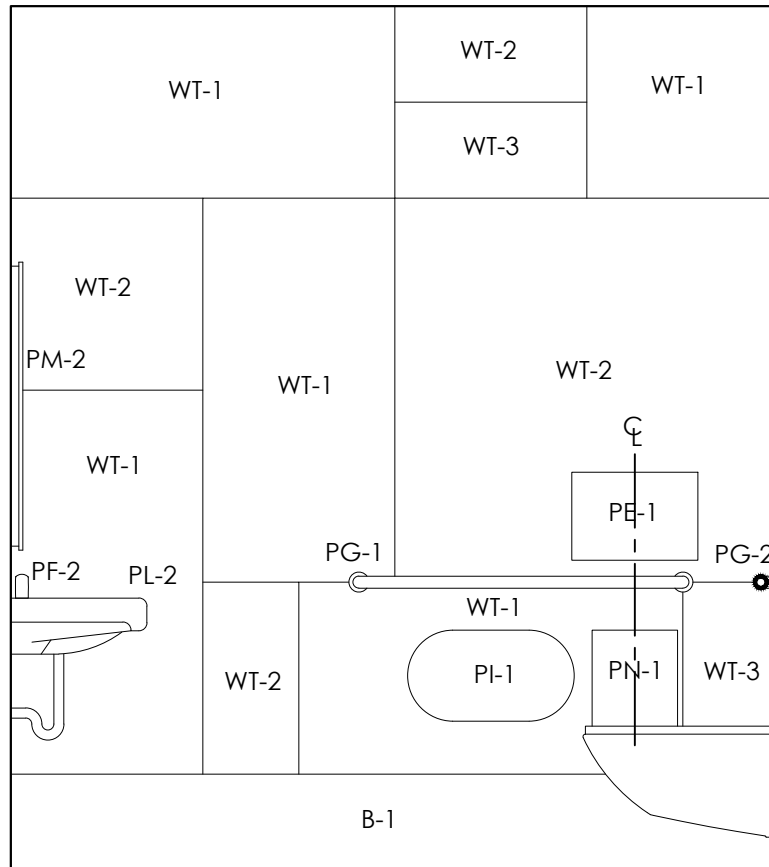
Scale: 1/2"=1'-0"

Reference TAS guidelines for spacing and mounting height requirements.

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1. Family Room Elevation

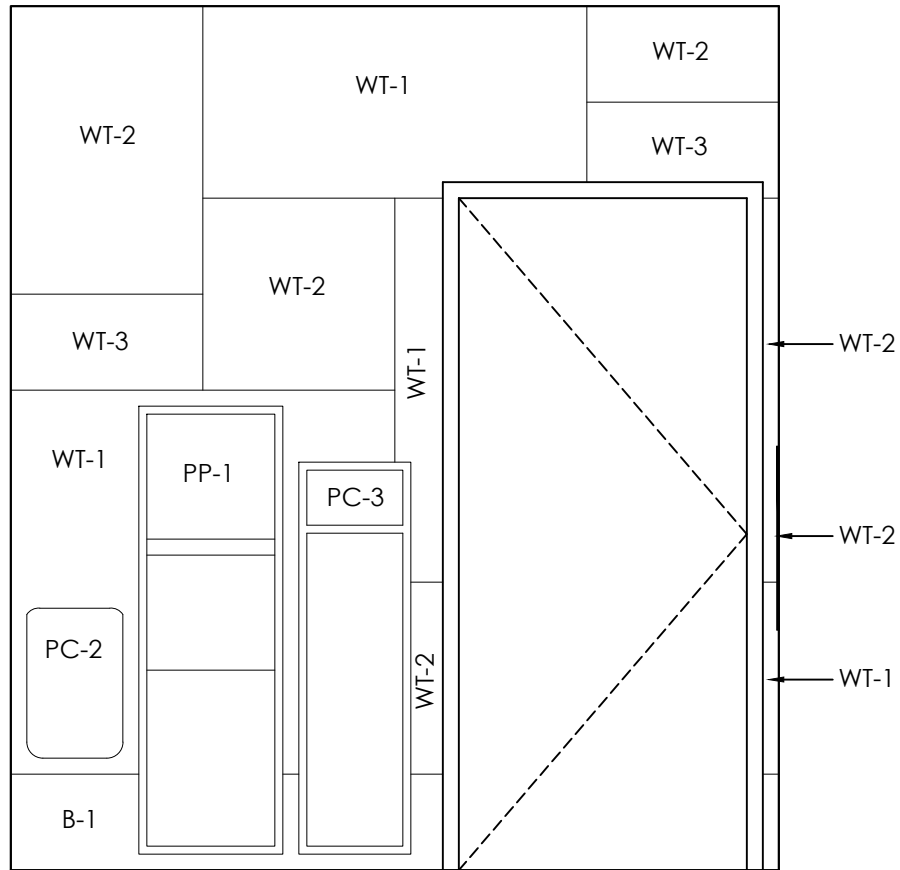
Scale: 1/2"=1'-0"

Reference TAS guidelines for spacing and mounting height requirements.

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1. Family Room Elevation

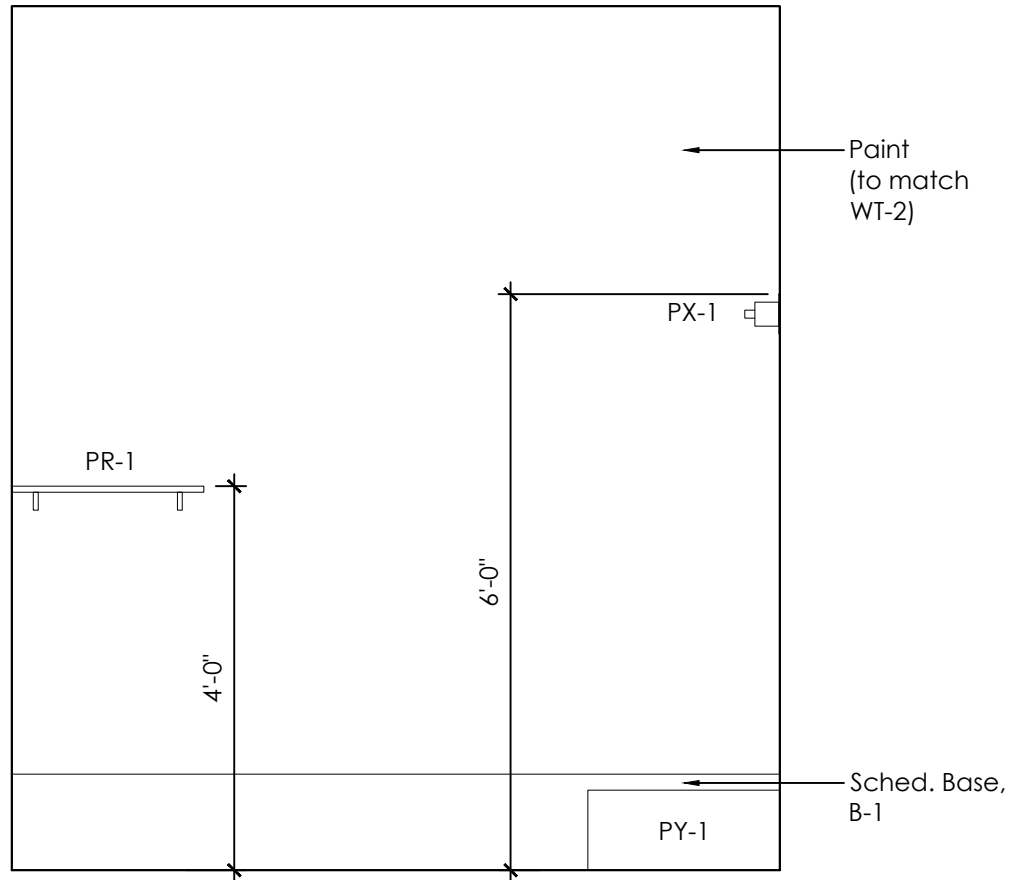
Scale: 1/2"=1'-0"

Reference TAS guidelines for spacing and mounting height requirements.

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1. Janitor Room Elevation

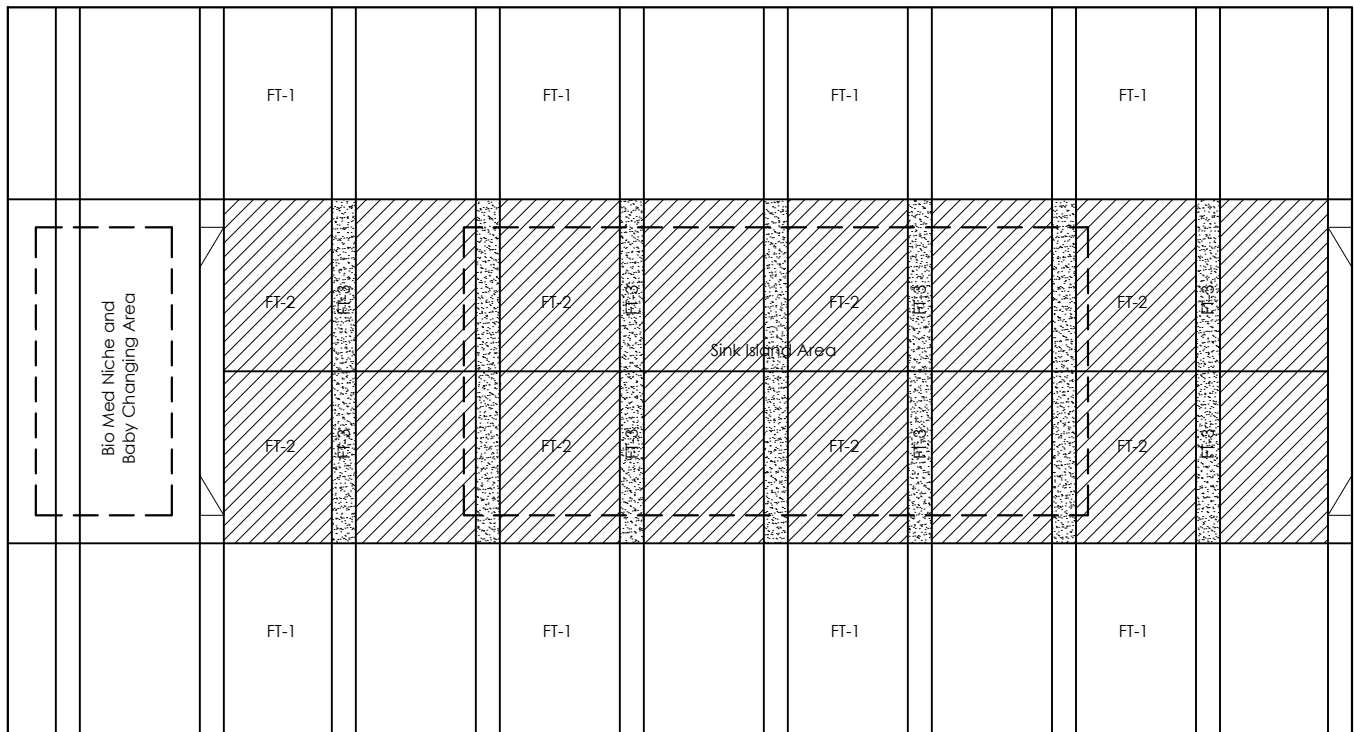
Scale: 1/2"=1'-0"

Reference TAS guidelines for spacing and mounting height requirements.

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1. Typical Restroom Floor Finish Plan

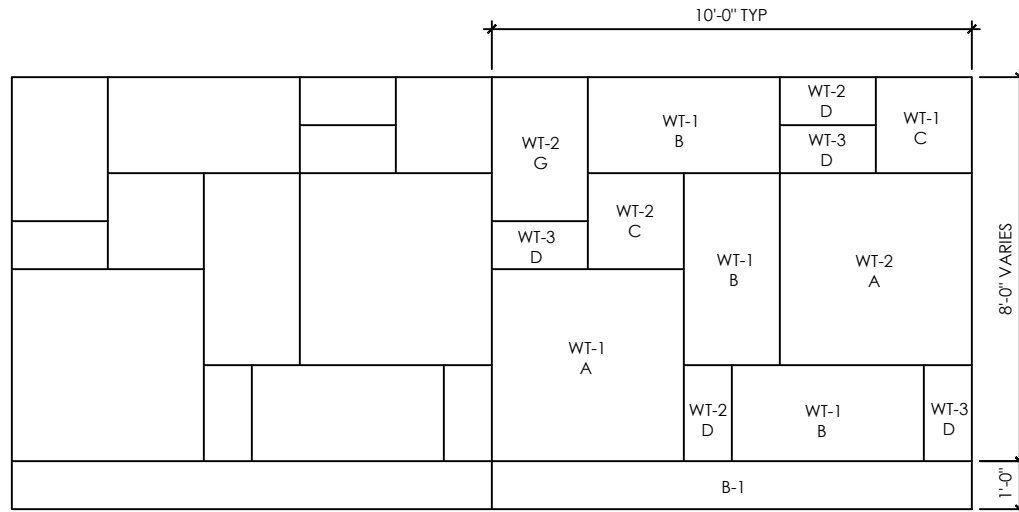
Scale: 1/4"=1'-0"

Large format tile floor finish transitions to align with ceiling finish transitions above, except where dimensioned. Large format tile size shall be 18 by 36 inches maximum.

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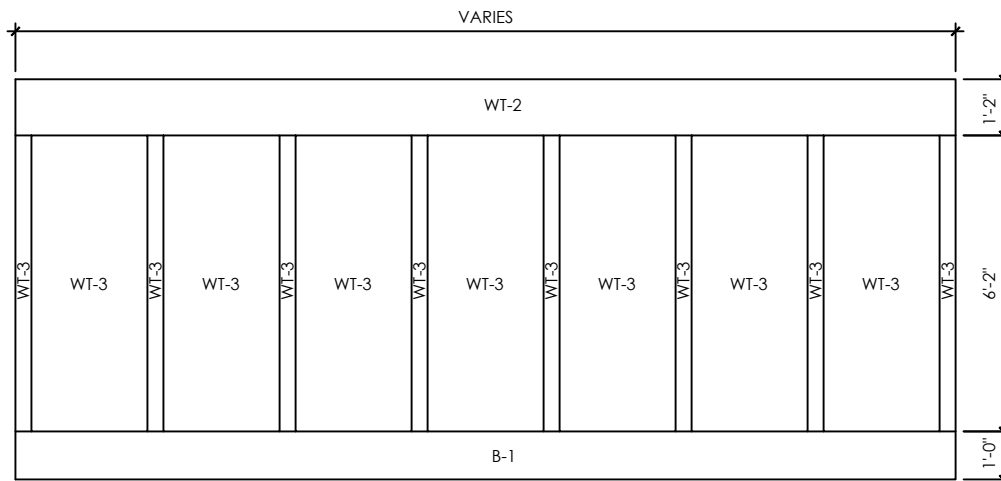


A	1200mm X 1200mm	E	300mm X 300mm
B	1200mm X 600mm	F	900mm X 300mm
C	600mm X 600mm	G	900mm X 600mm
D	600mm X 300mm	H	1200mm X 900mm

1. Wall Finish Elevation

Scale: 1/4"=1'-0"

Wall finish pattern to be continuous throughout restrooms except where noted on urinal & toilet wet walls.



2. Wall Finish Elevation

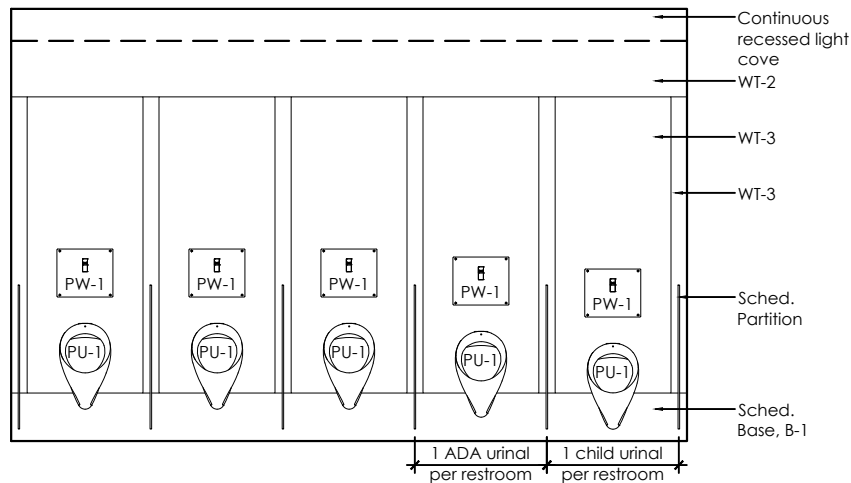
Scale: 1/4"=1'-0"

Wall finish pattern (Monolithic) on urinal & toilet wet walls.

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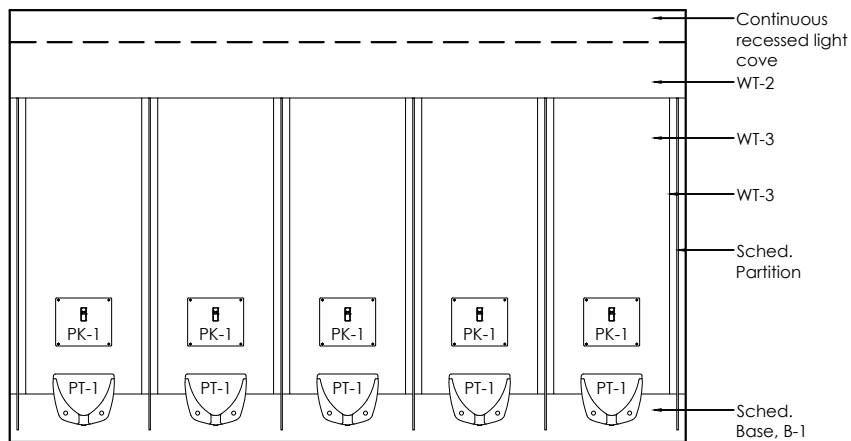
Issued: February 7, 2020



1. Men's Urinals Elevation

Scale: 1/4"=1'-0"

Total number of urinals depends on occupancy count per IBC and consequent plumbing fixture counts as stated in IPC. Each Men's restroom shall have one ADA compliant urinal along with one child accessible urinal. Reference TAS guidelines for spacing and mounting height requirements.



2. Typical Toilet Partition Elevation

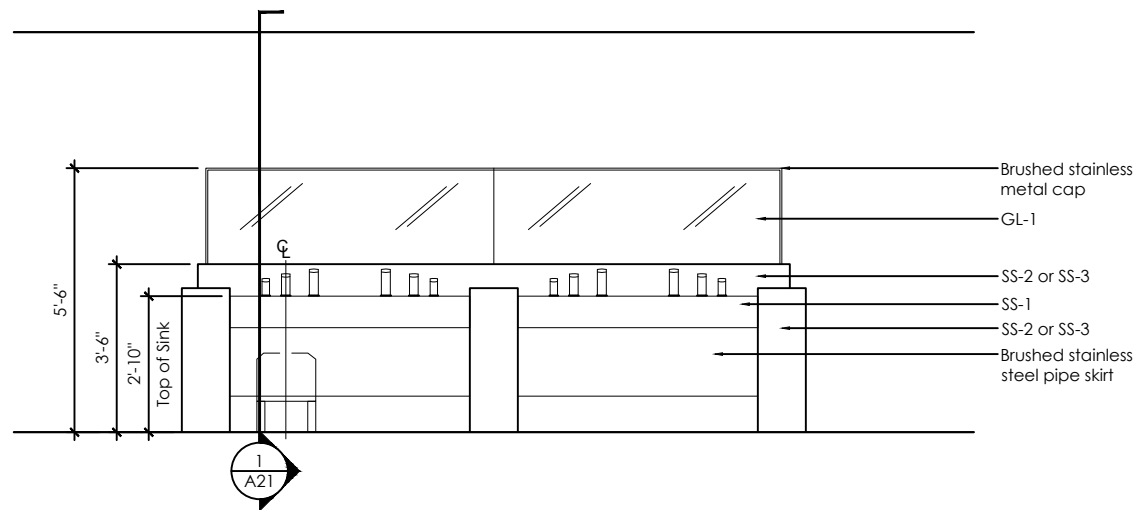
Scale: 1/4"=1'-0"

Each Men's and Women's Restroom shall have standard toilet stalls as illustrated in the elevation. The number of stalls is dependent upon occupancy type as stated in IBC and minimum fixture count as required per IPC.

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1. Typical Sink Island Elevation

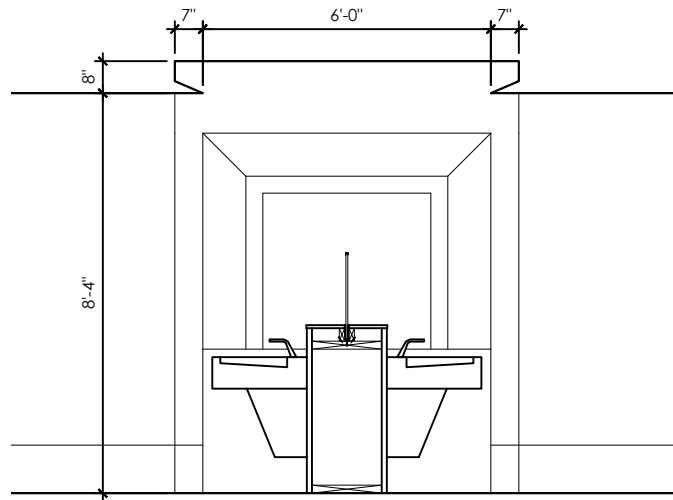
Scale: 1/4"=1'-0"

The Men's and Women's Sink Island are nearly identical. The design intention of the Sink Island is to prevent spillage of water and to reduce maintenance needs. Height of all sinks is to be compliant with ADA and TAS requirements. Each sink is to be adjacent to a soap dispenser, faucet, and hand-dryer for user's convenience. At wall-mounted sinks PM-2 will be used in lieu of GL-1.

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1. Typical Cross-Section at Sink Island

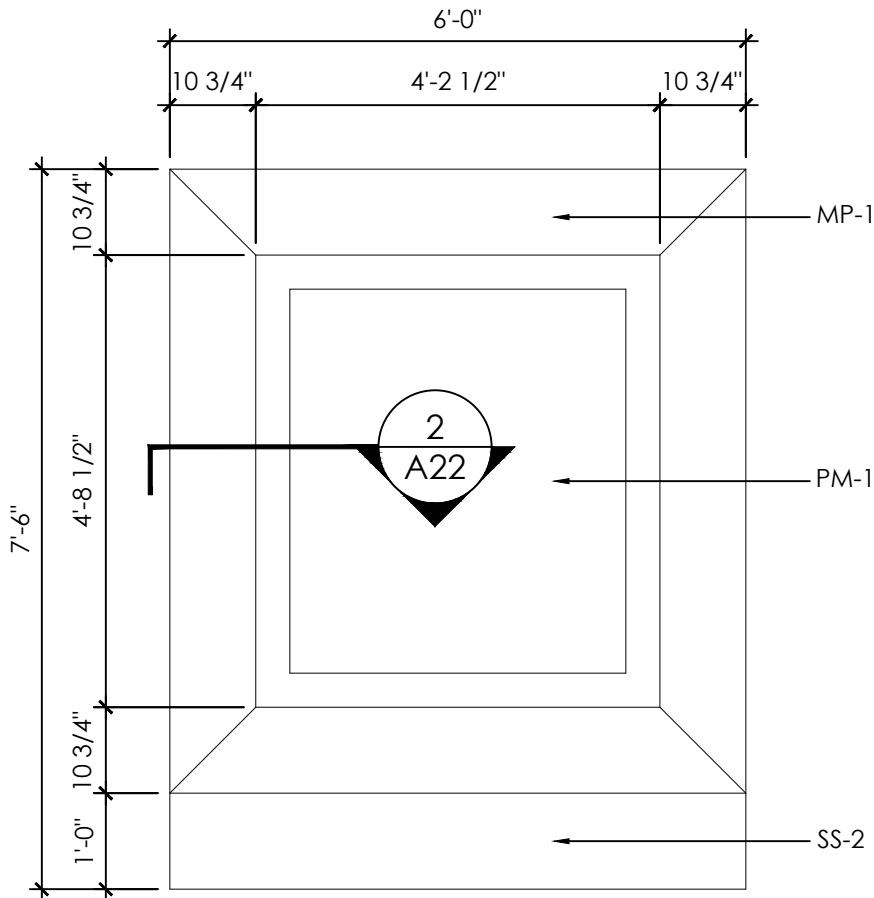
Scale: 1/4"=1'-0"

Both the Men's and Women's Restroom have similar cross-sections at the Sink Island. The exception is that the Men's drop down ceiling above the Sink Island is smaller in width and there are urinals to one side of the Sink Island.

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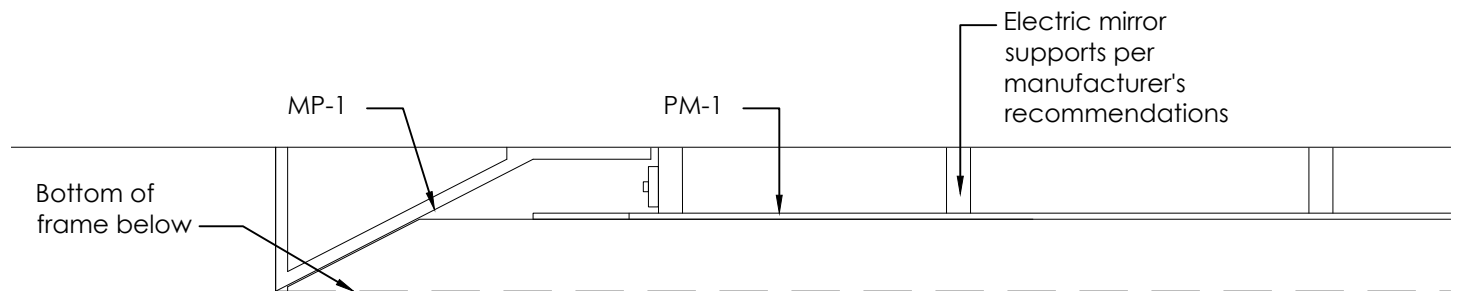
Issued: February 7, 2020



1. Typical Sidelit Mirror Elevation

Scale: 1/2"=1'-0"

Located inside restrooms on opposite sides of Sink Island.



2. Typical Sidelit Mirror Sectional Plan

Scale: 1 1/2"=1'-0"

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Section 4.1 Interior Finishes

Flooring:

FT-1

Product: Porcelain Floor Tile (white field)

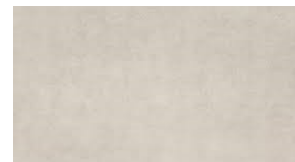
Manufacturer: Crossville

Collection: Laminam

Color: Fokos 5.6 Sale

Representative: Dave Painter

Phone: 346.221.5069



FT-2

Product: Porcelain Floor Tile (grey accent)

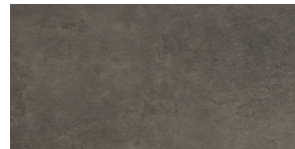
Manufacturer: Crossville

Collection: Laminam

Color: Fokos 5.6 Piombo

Representative: Dave Painter

Phone: 346.221.5069



FT-3

Product: Porcelain Floor Tile
(dark grey accent bar)

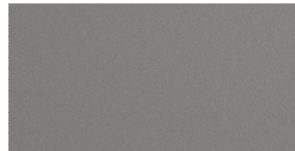
Manufacturer: Crossville

Collection: Laminam

Color: Foundations 5.6 Fumo

Representative: Dave Painter

Phone: 346.221.5069



Base:

WB-1

Product: Wall Tile Base

Manufacturer: Crossville

Collection: Laminam

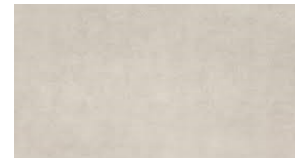
Color: Fokos 5.6 Sale (to match FT-1)

Size: 12" high, length varies,

refer to elevations, 10'-0" max length

Representative: Dave Painter

Phone: 346.221.5069



Millwork:

SS-1

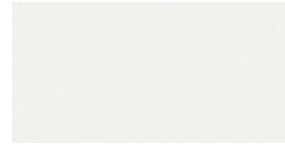
Product: Solid Surface (white sink)

Manufacturer: Silestone

Color: Blanco Maple

Representative: Kip Alstaetter

Phone: 713.590.0660



SS-2

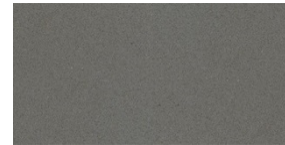
Product: Solid Surface (grey dividers)

Manufacturer: Silestone

Color: Gris Expo

Representative: Kip Alstaetter

Phone: 713.590.0660



SS-3

Product: Solid Surface (blue accent)

Manufacturer: Corian

Color: Elderberry

Representative:

Phone:



Wall Tile:

WT-1

Product: Wall Panel (grey field)

Manufacturer: Trespa

Collection: Virtuon

Color: K 03.4.0 Silver Grey

Size: Varies, refer to elevations for size & color placement.

Finish: Satin

Thickness: 10 mm

Representative:

Phone:



WT-2

Product: Wall Panel (white accent)

Manufacturer: Trespa

Collection: Virtuon

Color: K 05.0.0 Pure White

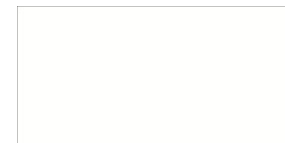
Size: Varies, refer to elevations for size & color placement.

Finish: Satin

Thickness: 10 mm

Representative:

Phone:



WT-3

Product: Wall Panel (dark grey accent)

Manufacturer: Trespa



Collection: Virtuon
 Color: K 21.7.0 Steel Grey
 Size: Varies, refer to elevations for size & color placement.
 Finish: Satin
 Thickness: 10 mm
 Representative:
 Phone:

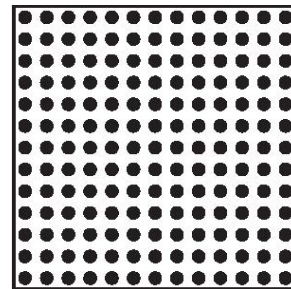
Metal:

MP-1
 Product: Custom Finish for Metal Frames
 Manufacturer: Gage Architectural Products
 Pattern: GM4225 (FRC)
 Representative: Brian Mc Closkey
 Phone: 281.460.4720 or 866.898.5262

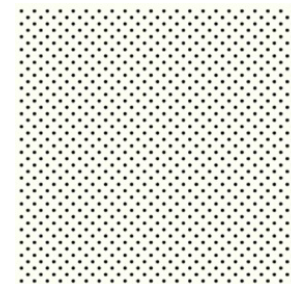


Ceiling:

MC-1
 Product: Metal Ceiling (white finish)
 Type: AV-3000, .040" thick aluminum
 Manufacturer: Gordon
 Product Number: R116-764ST23 Approx. 23% opening
 Panel Size: 2' x 2'
 Perforation Size: 1/16" holes x 7/64" straight centers
 Finish: PDR30113 Acroguard Bianco Mill Finish
 Description: Perforated panels to have 1/4" solid border. Panel held in place by AV-3000 grid suspended above with torsion springs, no reveal. Include acoustical pads.
 Representative: Gaynor Sherer, Specified Interiors
 Email: gs@specinteriors.com
 Phone: 281-655-8433



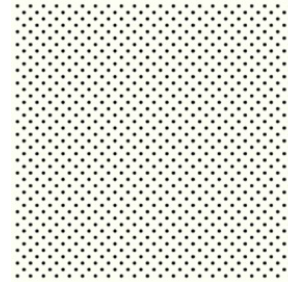
MC-2
 Product: Metal Ceiling (metallic finish)
 Type: 6" Marquis, .032" thick aluminum
 Manufacturer: Gordon
 Product Number: R116-532DG12 Approx. 12% opening
 Perforation Size: 1/16" holes on 5/32" diagonal center
 Finish: PDR30811 Acroguard Asti 11 Mill Finish / PDR30803 Acroguard Sterling Finish
 Description: Panels to have 1/4" solid border. Panel held in place by AV-3000 grid suspended above with torsion springs, no reveal. Include acoustical pads.
 Representative: Gaynor Sherer, Specified Interiors



Email: gs@specinteriors.com
Phone: 281-655-8433



MC-3
Product: Metal Ceiling (metallic finish)
Type: 3 ½" Marquis, .040" thick aluminum
Manufacturer: Gordon
Product Number: R116-764ST23 Approx. 23% opening
Perforation Size: 1/16" holes x 7/64" straight centers
Finish: PDR30811 Acrogard Asti 11 Mill Finish /
PDR30803 Acrogard Sterling Finish
Description: Panels to have 1/4" solid border. Panel held in place by AV-3000 grid suspended above with torsion springs, no reveal. Include acoustical pads.
Representative: Gaynor Sherer, Specified Interiors
Email: gs@specinteriors.com
Phone: 281-655-8433



Glass:

GL-1
Product: Glass Partition
Manufacturer: Skyline Design
Design: Custom Line Pattern Two Sided
Side 1: Custom Etched Pattern
Side 2: Custom Etched Pattern
Spec Sample #: 115575-001
Representative: Jessica Graham
Phone: 512-771-1295

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Section 4.2 Lighting Fixtures

L-1

Product: Downlight

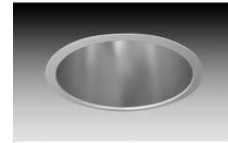
Manufacturer: Focal Point

Series: id

Model No.: FL6D-20LED-L40-RO-T

Description: 6" aperture LED

Note: Mounting per ceiling material type



L-2

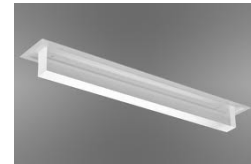
Product: Architectural Lighting

Manufacturer: Mark

Series: Fin

Description: 2'Lx4"W, Clear sides Frosted edges, LED

Note: Mounting for metal ceiling



L-3

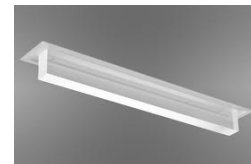
Product: Architectural Lighting

Manufacturer: Mark

Series: Fin

Description: 3'Lx4"W, Clear sides Frosted edges, LED

Note: Mounting for metal ceiling



L-4

Product: Architectural Lighting

Manufacturer: Mark

Series: Fin

Description: 4'Lx4"W, Clear sides Frosted edges, LED

Note: Mounting for metal ceiling



L-5

Product: 4' Luminaire LED

Manufacturer: Focal Point

Series: Trace LED cover

Model No.: FTRL

Description: Matte White Housing with frosted lens



L-6

Product: Slim LED Accent Luminaire

Manufacturer: Finelite

Series: Muro – Oval

Model No.: MU-O

Description: Wall Mounted White powder coat, LED



L-7

Product: LED Strip Light

Manufacturer: Diode LED

Series: Blaze high output LED strip light

Description: Field cuttable

Note: Driver is specified separately from fixture.
Provide constant voltage driver. Provide 4200K
LED.



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Section 4.3 Toilet Accessories & Plumbing Fixtures

PA-1

Product: Toilet Seat

Manufacturer: Toto

Model No.: SC534

Description: #01 Cotton

Representative: Hannah Petro

Email: hpetro@totusa.com

Phone: 312-661-0876 x200



PB-1

Product: Bed Liner Dispenser

Manufacturer: Koala Kare

Model No.: KB134-SSLD

Description: Stainless Steel, Recessed,
Stock with bed liner sheets: KB 150-99



PC-1

Product: Baby Changing Station

Manufacturer: Koala Kare

Model No.: KB110-SSRE

Description: Stainless Steel, Horizontal
Recess mounted



PC-2

Product: Child Seat

Manufacturer: Koala Kare Products

Model No.: KB102-00

Description: High-density Polyethylene



PC-3

Product: Waste Receptacle for Baby Products

Manufacturer: Bradley

Model No.: 315-35

Description: Stainless Steel, Recessed



PC-4
Product: Baby Changing Station
Manufacturer: Koala Kare
Model No.: KB112-01RE
Description: Recess mounted
for countertop surfaces



PD-1
Product: Hand Sanitizer Dispenser
Manufacturer: Purell
Model No.:
Description: Touch free hand, Black/Chrome,
1200 ml, to be supplied with Purell gel
Representative:
Email:
Phone:



PE-1
Product: Toilet Seat Cover Dispenser
Manufacturer: Bobrick
Model No.: B-221
Description: Stainless Steel, Surface mounted
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PF-1
Product: Ribbon Hand Dryer
Manufacturer: Lovair
Model No.: L-R031
Description:
Finish: Satin finish chrome
Representative:
Email:
Phone:



PF-2
Product: Ribbon Faucet
Manufacturer: Lovair
Model No.: L-R021
Description:
Finish: Satin finish chrome
Representative:
Email:
Phone:



PG-1

Product: Grab Bar 42"
Manufacturer: Bobrick
Model No.: B-5806
Description: Stainless Steel
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PG-2

Product: Grab Bar 36"
Manufacturer: Bobrick
Model No.: B-5806
Description: Stainless Steel
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PH-1

Product: Child Step Stool
Manufacturer: Step 'n Wash
Model No.: SNW-SS 975B
Description: Floor mounted, Self-retracting step stool at sink
Representative:
Email:
Phone:



PI-1

Product: Toilet Tissue Dispenser
Manufacturer: Bobrick
Model No.: B-2892
Description: Surface-mounted
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PJ-1

Product: Coat Hook
Manufacturer: Bobrick
Model No.: B-6777
Description: Satin-finish Stainless Steel Hook
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PK-1

Product: Toilet Flush – with chase

Manufacturer: Toto

Model No.: TET3LN

Description: Flushometer Valve, wall mounted,
for scenarios with available walk-in chase

Finish: Satin finish

Representative: Hannah Petro

Email: hpetro@totusa.com

Phone: 312-661-0876 x200



PK-2

Product: Toilet Flush – without chase

Manufacturer: Toto

Model No.: TET2LN

Description: Flushometer Valve, surface mounted,
for scenarios without available walk-in chase

Finish: Satin finish

Representative: Hannah Petro

Email: hpetro@totusa.com

Phone: 312-661-0876 x200



PL-1

Product: Lavatory

Manufacturer: Lovair

Model: L-S12

Description: Custom length with custom sink
depth (ref: Guideline drawings)

Finish: TBD

Representative:

Email:

Phone:



PL-2

Product: Wall Mounted Sink

Manufacturer: Kohler

Model No.: k-1999-1

Description: Wall-mounted

Finish: White finish

Email:

Phone:



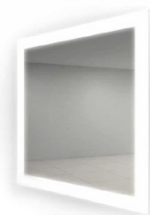
PM-1

Product: Electric Mirror

Manufacturer: Silhouette lighted mirror

Model No.: SIL-66.00x57.00-LD-M

Description: Standard size 60"W x 36"H
(Rotate sideways so 36" is width),
277V, LED lighting



Representative: Deidra Lashmet
Email: djlashmet@gmail.com
Phone: 785-341-2388

PM-2
Product: Carvart Floating Mirror
Manufacturer: Carvart
Model No.:
Description: 4MM thick with polished edges
Representative: Gaynor Sherer, Specified Interiors
Email: gs@specinteriors.com
Phone: 281-655-8433



PN-1
Product: Sanitary Napkin Disposal
Manufacturer: Bobrick
Model No.: B-254
Description: Surface mounted
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PO-1
Product: Ribbon Soap Dispenser
Manufacturer: Lovair
Model No.: L-R011
Description: Satin finish
Representative:
Email:
Phone:



PP-1
Product: Automatic Paper Towel & Waste
Receptacle unit
Manufacturer: Bobrick
Model No.: B-3974
Description: Recessed Convertible
Representative: John Cox
Email: jcox@peerlessmarketing.com
Phone: 281-450-7482



PQ-1
Product: Waste Receptacle
Manufacturer: Bobrick
Model No.: B-3644
Description: Recessed Convertible
Representative: John Cox
Email: jcox@peerlessmarketing.com



Phone: 281-450-7482

PR-1

Product: Shelf

Manufacturer: Bobrick

Model No.: B-298

Description: Stainless Steel, 24" long

Representative: John Cox

Email: jcox@peerlessmarketing.com

Phone: 281-450-7482



PS-1

Product: Sharps Disposal Container

Manufacturer: Plasti-Products

Model No.: 143002

Description: Wall mounted

Representative:

Email:

Phone:



PT-1

Product: Toilet

Manufacturer: Toto

Model No.: CT708EVG

Description: Wall mounted

Representative: Hannah Petro

Email: hpetro@totusa.com

Phone: 312-661-0876 x200



PU-1

Product: Urinal

Manufacturer: Toto

Model No.: UT104EV

Description: #01 Cotton color

Representative: Hannah Petro

Email: hpetro@totusa.com

Phone: 312-661-0876 x200



PV-1
 Product: Water Bottle Refill Station
 Manufacturer: Halsey Taylor
 Model No.: Hydroboost
 Description: Type of mounting depends on existing conditions, In-wall design preferred
 Representative:
 Email:
 Phone:



Field Retro-Fit Kit



Combination Kit



In-Wall Design



Surface Mount

PW-1
 Product: Urinal Flush – with chase
 Manufacturer: Toto
 Model No.: TEU3LN
 Description: Satin finish
 Representative: Hannah Petro
 Email: hpetro@totusa.com
 Phone: 312-661-0876 x200



PW-2
 Product: Urinal Flush – without chase
 Manufacturer: Toto
 Model No.: TEU2LN
 Description: Satin finish
 Representative: Hannah Petro
 Email: hpetro@totusa.com
 Phone: 312-661-0876 x200



PX-1
 Product: Mop & Broom Holder
 Manufacturer: Bobrick
 Model No.: B-223
 Description: 24" long
 Representative: John Cox
 Email: jcox@peerlessmarketing.com
 Phone: 281-450-7482



PY-1
Product: Mop Sink
Manufacturer: Zurn
Model No.: 1996-24
Description: Floor Mounted 24"x24"



PZ-1
Product: Toilet Stall Partition
Manufacturer: Carvart
Model: Color Glass Boxes
Series: Boxes
Glass Door Exterior: White Glossy Finish
Glass Door Interior: White Non-Glossy Finish
Divider: White Non-Glossy Finish,
High-Pressure Phenolic Laminate (HPL)
View: O (Opaque)
Finish: Satin Aluminum
Hardware: Pull hardware with occupancy
Indicator, continuous concealer at door edges,
out-swinging door on pivot hinge with rotating
floor pedestal
Mount: Double top bracket support
Representative: Gaynor Sherer, specified interiors
Email: gs@specinterior.com
Phone: 281-655-8433

PZ-2
Product: Urinal Stall Partition
Manufacturer: Carvart
Model: Color Glass Boxes
Series: Boxes
Glass Divider: White Non-Glossy Finish
View: O(opaque)
Finish: Satin Aluminum
Representative: Gaynor Sherer, specified interiors
Email: gs@specinterior.com
Phone: 281-655-8433