City of Houston - Department of Aviation – Infrastructure Division

PROJECT MANUAL

KENSWICK DRIVE EXTENSION
GEORGE BUSH INTERCONTINENTAL AIRPORT (IAH)

HAS PROJECT No.: 935

HAS Contract No.: LOA 715G-015

VOLUME NO. 3 OF 3 TOTAL VOLUMES

Texas Department of Transportation and City of Houston Specifications

May 23, 2024

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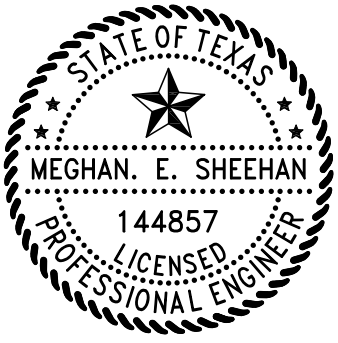

05/23/2024

TECHNICAL SPECIFICATIONS
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The following section contains technical specifications to be utilized on this project. Specifications are based on City of Houston (COH) Construction Specifications, 2022 Revision.

The following terms as they appear in the Technical Specifications shall be defined as follows:

Owner/Airport: Houston Airport Systems
Design Engineer: AtkinsRéalis North America
Engineer: Owner's Authorized Representative

Civil Specifications

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SECTION 02086

ADJUSTING MANHOLES, INLETS, AND VALVE BOXES TO GRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Adjusting elevation of manholes, inlets, and valve boxes to new grades.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for adjusting manhole frames and covers, inlets, valve boxes, and meter boxes to grade for new construction under this Section. Include payment in unit price for related item.

2. Payment for adjusting existing manholes, frame and cover, inlets, valve boxes, and meter boxes to a new grade is on a unit price basis for each.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Provide concrete, conforming to requirements of Section 03315 - Concrete for Utility Construction.

B. Provide precast concrete manhole sections and adjustment rings conforming to requirements of Section 02082 - Precast Concrete Manholes.

C. Provide mortar conforming to requirements of Section 04061 - Mortar.

2.02 CAST-IRON MATERIALS

A. Provide cast-iron materials conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

2.03 PIPING MATERIALS

A. For riser pipes and fittings, refer to Sections 02501 - Ductile-Iron Pipe and Fittings through 02528 - Polyethylene Encasement Wrap.

2.04 MASONRY MATERIALS FOR STORM SEWER MANHOLES AND INLETS

A. Provide brick masonry units conforming to the requirements of Section 04210 - Brick Masonry for Utility Construction.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine existing structure, valve box, frame and cover or inlet box, frame and cover or inlet, piping and connections for damage or defects affecting adjustment to grade. Report damage or defects to Project Manager.

3.02 ESTABLISHING GRADE

A. Coordinate grade related items with existing grade and finished grade or paving, and relate to established bench mark or reference line.

3.03 ADJUSTING MANHOLES AND INLETS

A. Rebuild adjustment portion of manhole or inlet by adding or removing Adjustments. Follow procedures for the type of structure being adjusted detailed in the following Sections:

1. Section 02081 - Cast-In-Place Concrete Manholes

2. Section 02082 - Precast Concrete Manholes

3. Section 02083 - Fiberglass Manholes

4. Section 02632 - Cast-In-Place Inlets, Headwalls and Wingwalls

5. Section 02633 - Precast Concrete Inlets, Headwalls and Wingwalls

B. Salvage and reuse cast-iron frame and cover or grate.

C. Protect or block off manhole or inlet bottom using wood forms shaped to fit so that no debris or soil falls to bottom during adjustment.

D. Verify that manholes and inlets are free of visible leaks as result of reconstruction. Repair leaks in manner subject to Project Manger's approval.

3.04 ADJUSTING VALVE BOXES

A. Salvage and reuse valve box and surrounding concrete block as approved by Project Manager. No separate pay.

B. Remove and replace 6 inch ductile iron riser pipe with suitable length for depth of cover required to establish adjusted elevation to accommodate actual finish grade.

C. Reinstall valve box and riser piping plumbed in vertical position. Provide minimum 6 inches telescoping freeboard space between riser pipe top butt end and interior contact flange of valve box for vertical movement damping.

D. After valve box has been set, aligned, and adjusted so that top lid is level with final grade.

3.05 BACKFILL AND GRADING

A. Backfill area of excavation surrounding each adjusted manhole, inlet, and valve box and compact according to requirements of Section 02316 - Excavation and Backfill for Structures.

B. Grade ground surface to drain away from each manhole and valve box. Place earth fill around manholes to level of upper rim of manhole frame. Place earth fill around valve box concrete slab.

C. In unpaved areas, grade surface at uniform slope of 1 to 5 from manhole frame to natural grade. Provide minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Provide seeding in accordance with Section 02921 – Hydro Mulch Seeding, or if sodding in accordance with Section 02922 - Sodding.

END OF SECTION

SECTION 02136

WASTE MATERIAL HANDLING, TESTING AND DISPOSAL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Handling, testing and disposal of hazardous and non-hazardous waste material.

B. Material present inside of existing tanks to be repaired or demolished, i.e., silt, sludge and other residue deposits generated by normal water production usage of the tanks.

C. Existing coatings removed from existing tanks.

D. Spent abrasives used and debris generated in the execution of the work.

E. All spent thinners, coating materials or other products brought on site for execution of work that require disposal as a hazardous or non-hazardous waste.

F. Soil that may be contaminated due to the execution of the work.

G. Petroleum soaked sand foundation material removed from demolished tank sites.

1.02 MEASUREMENT AND PAYMENT

A. No separate measurement and payment will be made for handling, testing or disposal of non- hazardous or hazardous material, debris or material identified as contaminated material on the site prior to the bid date except as indicated in section 1.02 B and 1.02 C. The Contractor shall include the cost for this work in the Contract bid price for work of which this is a component part.

B. Payment for hazardous waste material handling, removal, testing, transporting and disposal of material identified as hazardous after the bid date will be paid for at the unit price bid for "Hazardous Waste Handling, Removal, Transporting" if such an item is provided in the contract.

C. Removal and disposal of potentially petroleum soaked sand foundation material will be measured per cubic yard which shall include testing, removing, storing, transporting and disposing of material and will be paid for at the unit price bid for "Removal and Disposal of Potentially Petroleum Soaked Sand". Basis of payment will be Class I Industrial Waste having a Total Petroleum Hydrocarbon (TPH) level greater than 1500 ppm.

1.03 REFERENCES

The following is a list of applicable requirements to this project. It is not intended to be a complete listing of all laws and regulations to which the Contractor must comply.

A. Environmental Protection Agency - Code of Federal Regulations

1. 40 CFR Part 261 - Identification and Listing of Hazardous Waste

2. 40 CFR 261, Appendix II EPA - Toxicity Characteristic Leaching Procedure

3. 40 CFR Part 262 - Standards Applicable to Generators of Hazardous Waste

4. 40 CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste

5. 40 CFR Part 264 - Standards for Owner and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

6. 40 CFR Part 265 - Interim Status for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

7. 40 CFR 265, Subpart C EPA - Preparedness and Prevention

8. 40 CFR 265, Subpart D EPA - Contingency Plan and Emergency Procedures

9. 40 CFR 265.16 EPA - Personnel Training

10. 40 CFR Part 268 - Land Disposal Restrictions

11. 49 CFR Parts 173 – Shippers – General Requirements for Shipments and Packaging’s

12. 49 CFR Part 178 – Specifications for Packaging’s

13. 49 CFR Part 179 – Specifications for Tank Cars

14. 40 CFR Part 355 - Emergency Planning and Notification

B. EPA Methods

1. 3050 - Acid Digestion of Sediment, Sludge, and Soils

2. SW 846 - Test Methods for Evaluating Solid Waste - Physical/Chemical Methods

C. Texas Commission on Environmental Quality

1. TAC Title 30, Chapter 305 "Consolidated Permits"

2. TAC Title 30, Chapter 335 "Industrial Solid Waste and Municipal Hazardous Waste"

3. TAC Title 30, Chapter 343 "Oil and Hazardous Substances"

D. TWC Technical Guidelines

1. Document #1, Waste Evaluation/Classification

E. NIOSH Methods

1. 7082 LEAD by Flame AAS

F. Society for Protective Coatings

1. SSPC 91-18 - Industrial Lead Paint Removal Handbook

2. Guide 6 - Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations

3. Guide 7 - Guide for the Disposal of Lead Contaminated Surface Preparation Debris

1.04 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 – Submittal Procedures.

B. Submittals shall conform to appropriate codes for regulatory requirements.

C. Obtain and submit disposal permits for proposed disposal sites, if required by local ordinances.

1.05 TESTING AND IDENTIFICATION

A. The Owner is the Generator of the debris for permitting purposes, and will obtain the EPA Identification number, but the Contractor is responsible for assuring that all testing, handling, storage, transportation, and disposal requirements are properly implemented, including satisfactory training of job site personnel and the cleaning of all reusable items and equipment prior to removal from the site.

B. Prior to the bid date, if testing has been performed by the City and if hazardous material has been identified in the debris material in an existing tank, the paint to be removed from an existing tank, the work site soil, or the foundation material, the material or test results will be indicated in Section 01110 – Summary of Work. It is the responsibility of the

Contractor to properly test and to determine if any wastes generated as a result of this project are hazardous in accordance with 40 CFR Part 261.

1.06 DEFINITIONS

(Note Definitions applicable to this section are also presented elsewhere.)

A. Hazardous Waste (lead paint debris): Waste that is classified as hazardous due to its concentrations of regulated hazardous substances. Paint debris is classified as hazardous waste if, after testing by the Toxicity Characteristic Leaching Procedure (TCLP), the leachate contains any of the 8 metals or other substances in concentrations at or above limits established in 40 CFR 261.

B. Lead Containing Dust and Debris: Dust and debris generated during the project which contains lead in any amount, including but not limited to pulverized paint, spent abrasive, filters (wet and dry), and containment materials upon which lead is still present.

C. RCRA: Resource Conservation and Recovery Act. Federal law pertaining to hazardous waste management. EPA implementing regulations are contained in 40 CFR 240-280.

D. TACB: Texas Air Control Board. Texas State Agency joined into the TCEQ and responsible for writing and enforcement of rules and regulations relating to air quality.

E. TCEQ: Texas Commission on Environmental Quality. State of Texas Commission responsible for planning, oversight, monitoring and management of natural resources.

F. TCLP: Toxicity Characteristic Leaching Procedure. Laboratory tests conducted on wastes that determine the amount of hazardous materials that leach out into a test solution. The test is intended to simulate the properties of water as it leaches through a solid waste landfill. TCLP testing is defined in 40 CFR 261, Appendix II.

G. TWC: Texas Water Commission. Texas State Agency joined into the TCEQ and responsible for writing and enforcement of rules and regulations relating to water quality and solid waste programs.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 WASTE HANDLING AND STORAGE

A. All chemicals to be brought on site by the contractor must be stored and used in a safe and proper manner in accordance with all applicable Federal, State and local laws and regulations as well as the manufacturers recommendations. Material Safety Data Sheets

(MSDSs) shall be maintained on-site for all hazardous chemicals used.

B. Hazardous wastes are to be handled and stored according to the requirements of TAC 30 Chapter 335 "Industrial Solid Waste and Municipal Hazardous Waste" and 40CFR Part 262, with regard to on-site storage, and 40CFR Part 264 with regard to required notices, site security, personnel training, contingency planning and emergency procedures, recordkeeping and reporting, time of storage, amount of material stored, and use of proper containers. Hazardous waste will be stored in covered containers in accordance with the requirements of 40 CFR 262 and 49 CFR 172,178 and 179.

C. The contractor shall provide proper, segregated storage for hazardous and non-hazardous materials to be used in the work area in order to ensure safe work conditions.

D. All material, waste and debris from removal of lead containing coatings, including those products and materials employed for chemical paint stripping, shall be considered hazardous waste and handled accordingly, until such time that testing and analysis indicates otherwise.

1. Sampling of materials for TCLP testing of initial containers of debris shall be completed prior to or during filling. Until the TCLP test results are received, the containers shall be labeled as lead-containing debris. Hazardous waste labels shall be applied after the test results are received, if the debris tests hazardous.

2. Hazardous waste shall not be stored at the project site for more than 90 days. Non-hazardous wastes shall be removed at a minimum of once per month (30 days).

3. Special attention shall be given to the time of storage, storage conditions, amount of material stored at any one time, use of proper containers, and personnel training.

E. Hazardous waste shall be placed on pallets over protected ground, be located in a secure area enclosed by a fence with signs around the perimeter, and be shielded adequately to prevent dispersion of the waste by wind or water. Under no circumstances shall the waste be stored within a flood plain area. Any evidence of improper storage shall be cause for immediate shutdown of the project until corrective action is taken. The storage area shall be within a security fence with a locked gate.

3.02 ENVIRONMENTAL CONTAMINATION

The contractor shall not contaminate the air, soils or surface and ground waters with any hazardous waste. Spills, releases and discharges of hazardous or toxic materials which inadvertently occur shall be reported in accordance with 40 CFR 265 and TAC 30 Chapter 343.

A. Contingency Plan and Training: The Contractor shall comply with TCEQ Title 30 Regulations and EPA 40 CFR 265, Subpart C in the event of a spill or release of waste,

EPA 40 CFR 265 Subpart D, and TCEQ regulations.

B. All personnel associated with the handling of hazardous waste shall complete a formal training program in accordance with 40 CFR 265.16 and TCEQ Title 30 Regulations. Training records of all employees must be maintained and kept on file.

3.03 WASTE CLASSIFICATION

A. Testing

1. All solid waste generated by the paint removal activities shall be tested in accordance with 40 CFR 261, Appendix II, Method 1311 Toxicity Characteristic Leaching Procedure (TCLP), to determine if it is hazardous.

2. In the case of wet methods of preparation, the use of chemical strippers, or containerized hygiene water, all liquids and sludge shall also be tested. When chemical strippers are used, the testing shall include pH to determine corrosivity. All waste water shall be tested for total lead.

3. Representative samples of the debris for each waste stream generated from the work on this project shall be collected. A minimum of four of the samples representative of each waste stream shall be analyzed to establish a waste is non-hazardous. Note that more than four initial samples of each waste stream shall be collected in order to obtain the four representative samples for analysis. Results from one test sample are sufficient to identify a waste as hazardous.

4. The collection of the initial representative samples of each waste stream and selection of the minimum of four for testing shall be accomplished using a random sampling technique and shall comply with the following: a minimum of one representative sample for each 55 gallons of waste, or a minimum of four representative samples for each gondola or roll-off box of waste. Samples shall be collected in accordance with SW-846, "Test Methods for Evaluating Solid Waste - Physical/ Chemical Methods".

5. Sampling and testing shall be performed by a certified laboratory acceptable to the Owner. The name, address, and qualifications of the laboratory shall be provided for approval. The Owner shall be provided with copies of the test results as soon as they are received by the Contractor.

B. Classification

1. Lead paint debris is classified as hazardous waste if, after testing by TCLP, the leachate contains any of the 8 metals or other hazardous substances in concentrations at or above limits established in 40 CFR 261:

Arsenic -	5.0 mg/L
Barium -	100.0 mg/L

Cadmium -	1.0 mg/L
Chromium -	5.0 mg/L
Lead -	5.0 mg/L
Mercury -	0.2 mg/L
Selenium -	1.0 mg/L
Silver -	5.0 mg/L

2. The above includes only the eight (8) characteristic metals listed by EPA among which are elements typically associated with paints. Other substances may be present which may cause debris to be classified as hazardous waste as defined in 40 CFR 261 (such as a pH<=2.0 or >=12.5 resulting in corrosivity), and must be taken into account.

3.04 DISPOSAL

A. The contractor shall arrange to have wastes and debris transported from the site in accordance with all City Ordinances and State and Federal Laws. If wastes and/or debris is determined to be hazardous, transporting to be in accordance with TAC 30 Chapter 335 - Industrial Solid Waste and Municipal Hazardous Waste, 40CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste and the applicable sections of 49 CFR Parts 171 through 179.

B. Manifest and Reporting: The Contractor shall comply with all of the manifesting, certification, and reporting requirements of EPA 40 CFR 262, 40 CFR 268, and Texas regulations, including certificates of final disposal for each shipment.

C. Copies of all records and reports, test sample chain of custody forms, TCLP and other test results shall be provided to the Owner.

D. The contractor shall dispose of wastes and debris at a licensed site acceptable to the Owner. Hazardous wastes and debris shall be disposed of in accordance with 40CFR Part 265 and 40CFR Part 268 Land Disposal Restrictions. Manifesting of hazardous wastes shall be in accordance with 40CFR Part 262, Subpart B.

E. Wastewater resulting from surface preparation, washing, personal hygiene or decontamination shall not be discharged without testing and through arrangement with the local Publicly Owned Treatment Works (POTW) or other approved means.

END OF SECTION

SECTION 02221

REMOVING EXISTING PAVEMENTS, STRUCTURES, WOOD, AND DEMOLITION DEBRIS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removing concrete paving, asphaltic concrete pavement, brick pavement and base courses.

B. Removing concrete curbs, concrete curbs and gutters, sidewalks and driveways.

C. Removing pipe culverts, sewers, and sewer leads.

D. Removing waterlines and water services lines including asbestos cement pipe per OSHA guidelines.

E. Removing existing inlets and manholes.

F. Removing and disposing of pre-stressed concrete beams and drill shafts.

G. Removing miscellaneous structures of concrete or masonry.

H. Removing existing bridge.

I. Removing existing wood and demolition debris.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for removing and disposing of asphaltic surfacing with or without base, regardless of thickness encountered, is on square yard basis measured between lips of gutters.

2. Payment for removing and disposing of reinforced concrete pavement, with or without asphalt overlay, regardless of its thickness, is on square yard basis measured from back- to-back of curbs. Payment includes concrete pavement, esplanade curbs, curbs and gutters, and paving headers.

3. Payment for removing and disposing of cement stabilized shell base course, with or without asphaltic surfacing, is on square yard basis.

4. Payment for removing and disposing of concrete sidewalks and driveways is on square yard basis.

5. Payment for removing asphaltic pavement surface by milling shall be in accordance with Section 2960 - Milling Pavement.

6. Payment for removing and disposing of miscellaneous concrete and masonry is on cubic yard basis of structure in place.

7. Payment for removing and disposing of pipe culverts, sewers, and sewer leads, is on linear foot basis for each diameter and each material type of pipe removed.

8. Payment for removing and disposing of waterlines and water service lines including asbestos cement pipe is on linear foot basis for each diameter pipe and each material type of pipe removed.

9. Payment for removing and disposing of existing inlets is on unit price basis for each inlet removed.

10. Payment for removing and disposing of prestressed concrete piles and drill shafts is on linear foot basis.

11. Payment for removing and disposing of existing bridge, including piles and abutments to minimum of 4 feet below ground level, is on a lump sum basis.

12. Payment for removing and disposing of existing manholes is on unit price basis for each manhole removed.

13. Payment for removing and disposing of miscellaneous wood and demolition debris is on cubic yard basis.

14. No payment for saw cutting of pavement, curbs, or curbs and gutters will be made under this section. Include cost of such work in unit prices for items listed in bid form requiring saw cutting.

15. No payment will be made for work outside maximum payment limits indicated on Drawings, or for pavements or structures removed for Contractor's convenience.

    a. For utility installations: Match actual pavement replaced but no greater than maximum pavement replacement limits shown on Drawings. Limits of measurement will be as shown on Street Cut Pavement Replacement Rules.

16. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work

in this Section is included in total Stipulated Price.

1.03 REGULATORY REQUIREMENTS

A. Conform to applicable codes for disposal of debris.

B. Coordinate removal work with utility companies.

C. For removal of asbestos containing materials, or material that could potentially contain asbestos, comply with applicable provisions of OSHA 29 CFR 1926.1101 – Asbestos, OSHA 29 CFR 1926.32 – General Safety and Health Provisions, and EPA 40 CFR 61 Subpart M – National Emission Standard for Asbestos.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 PREPARATION

A. Obtain advance approval from Project Manager for dimensions and limits of removal work.

B. Identify known utilities below grade. Stake and flag locations.

C. For removal of asbestos-containing materials, or materials that oculd potentially contain asbestos, comply with the following:

1. Crew members must be trained in accordance with OSHA 29 CFR 1926.1101 – Asbestos.

2. Conduct negative exposure assessment to demonstrate asbestos exposure below permissible exposure limit (PEL) in accordance with OSHA 29 CFR 1926.1101 – Asbestos and EPA 40 CFR 763 – Asbestos.

3. If negative exposure assessment not conducted, or if results are above PEL, provide respiratory protection in accordance with Paragraph 3.02 of this Section.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Adjacent public and private property.

2. Trees, plants, and other landscape features designated to remain.

3. Utilities designated to remain.

4. Pavement and utility structures designated to remain.

5. Bench marks, monuments, and existing structures designated to remain.

B. When required, provide respiratory protection in accordance with OSHA 29 CFR 1910.134 – Respiratory Protection, and National Institute of Occupational Safety and Health (NIOSH).

3.03 REMOVALS

A. Remove pavements and structures by methods that will not damage underground utilities. Do not use drop hammer near existing underground utilities.

B. Minimize amount of earth loaded during removal operations.

C. Where existing pavement is to remain, make straight saw cuts in existing pavement to provide clean breaks prior to removal. Do not break concrete pavement or base with drop hammer unless concrete or base has been saw cut to minimum depth of 2 inches.

D. When street and driveway saw cut location is greater than one-half of pavement lane width, remove pavement for full lane width or to nearest longitudinal joint as directed by Project Manager.

E. Remove sidewalks and curbs to nearest existing dummy, expansion, or construction joint.

F. Where existing end of pipe culvert or end of sewer is to remain, install 8-inch-thick masonry plug in pipe end prior to backfill in accordance with requirements of Section 02316 - Excavation and Backfill for Structures.

G. Labeling of Asbestos Cement (AC) Pipe:

1. Label leak-tight container with warning statement of hazardous asbestos content in accordance with OSHA 29 CFR 1926.1101 and as noted below.

2. Label waste material with following warning:

DANGER
CONTAINS ASBESTOS FIBERS
MAY CAUSE CANCER
CAUSES DAMAGE TO LUNGS
DO NOT BREATHE DUST
AVOID CREATING DUST

3. Neatly print labels in letters of sufficient size and contrast so label is easily visible and legible.

3.04 BACKFILL

A. Backfill of removal areas shall be in accordance with requirements of Section 02316 - Excavation and Backfill for Structures.

3.05 DISPOSAL

A. Inlet frames, grates, and plates; and manhole frames and covers, may remain City property. Disposal shall be in accordance with requirements of Section 01576 - Waste Material Disposal.

B. Remove from site, debris resulting from work under this section in accordance with requirements of Section 01576 - Waste Material Disposal.

C. For asbestos-containing materials:

1. Comply with 40 CFR Part 61 and 30 TAC Sections 330.137(b) for Industrial Class 1 waste.

2. Inspect load to ensure correct packaging and labeling.

3. Line vehicles with two layers of 6-mil polyethylene sheeting.

4. Remove asbestos-containing waste from site daily.

END OF SECTION

SECTION 02233

CLEARING AND GRUBBING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removing surface debris and rubbish.

B. Clearing site of plant life and grass.

C. Removing trees and shrubs.

D. Removing root system of trees and shrubs.

E. Fence removal.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for clearing and grubbing is on per acre basis.

2. No separate payment will be made for clearing and grubbing of wastewater projects, include payment in unit prices for related items.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REGULATORY REQUIREMENTS

A. Conform to applicable codes for disposal of debris.

B. Coordinate clearing work with utility companies.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that existing plant life and features designated to remain are identified and tagged.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Living trees located 3 feet or more outside of intersection of side slopes and original ground line.

2. Plants other than trees and landscape features designated to remain.

3. Utilities designated to remain.

4. Bench marks, monuments, and existing structures designated to remain.

3.03 CLEARING

A. Remove stumps, main root ball, and root system to:

1. Depth of 24 inches below finished subgrade elevation in area bounded by lines two feet behind back of curbs.

2. Depth of 24 inches below finished surface of required cross section for other areas.

B. Clear undergrowth and deadwood without disturbing subsoil.

C. Remove vegetation from top soil scheduled for reuse.

3.04 REMOVAL

A. Remove debris, rubbish, and extracted plant material life from site in accordance with requirements of Section 01576 - Waste Material Disposal.

B. Remove on site fences. Materials generated from removal of fences become property of Contractor. Properly dispose of in accordance with applicable local, state and federal laws.

END OF SECTION

SECTION 02260

TRENCH SAFETY SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Trench safety system for the construction of trench excavations.

B. Trench safety system for excavations which fall under provisions of State and Federal trench safety laws.

C. This Standard Specification Section replaces previously published Section 01561- Trench Safety System.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement for trench safety systems used on trench excavations is on a linear foot basis measured along the centerline of the trench, including manholes and other line structures.

2. No payment will be made under this section for trench safety systems for structural excavations, tunnel shafts, auger pits, or excavation for trenchless installations, and also for any necessary non trenchless installations included in the aforementioned methods of construction unless included as a bid item in Documents 00410 – Bid Form. Include payment for trench safety systems in applicable structural or utility installation sections.

3. Refer to Section 01270 - Measurement and payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 DEFINITIONS

A. A trench shall be defined as a narrow excavation (in relation to its depth) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet.

B. The trench safety system requirements will apply to larger open excavations if the erection of structures or other installations limits the space between the excavation slope and these installation to dimensions equivalent of a trench as defined.

C. Trench Safety Systems include but are not limited to sloping, sheeting, trench boxes or trench shields, sheet piling, cribbing, bracing, shoring, dewatering or diversion of water to provide adequate drainage.

D. Trench Safety Program is the safety procedures governing the presence and activities of individuals working in and around trench excavations.

1.04 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 - Submittal Procedures.

B. Submit a safety program specifically for the construction of trench excavation. Design the trench safety program to be in accordance with OSHA 29CFR standards governing the presence and activities of individuals working in and around trench excavations.

C. Construction and shop drawings containing deviations from OSHA standards or special designs shall be sealed by a licensed Engineer retained and paid by Contractor.

D. Review of the safety program by the City Engineer will only be in regard to compliance with this specification and will not constitute approval by the City Engineer nor relieve Contractor of obligations under State and Federal trench safety laws.

E. Submit certification that trench safety system will not be subjected to loads exceeding those which the system was designed to withstand according to the available construction and geotechnical information.

1.05 REGULATORY REQUIREMENTS

A. Install and maintain trench safety systems in accordance with the detail specifications set out in the provision of Excavations, Trenching, and Shoring, Federal Occupation Safety and Health Administration (OSHA) Standards, 29CFR, Part 1926, Subpart P, as amended, including Final Rule, published in the Federal Register Vol. 54, No. 209 on Tuesday, October 31, 1989. The sections that are incorporated into these specifications by reference include Sections 1926-650 through 1926-652.

B. A reproduction of the OSHA standards included in "Subpart P - Excavations" from the Federal Register Vol. 54, No. 209 is available upon request to Contractors bidding on City projects. The City assumes no responsibility for the accuracy of the reproduction. The Contractor is responsible for obtaining a copy of this section of the Federal Register.

C. Legislation that has been enacted by the Texas Legislature with regard to Trench Safety Systems, is hereby incorporated, by reference, into these specifications. Refer to Texas Health and Safety Code Ann., §756.021 (Vernon 1991).

D. Reference materials, if developed for a specific project, will be issued with the Bid Documents, including the following:

1. Document 00830 - Trench Safety Geotechnical Information: Geotechnical information obtained for use in design of the trench safety system.

1.06 INDEMNIFICATION

A. Contractor shall indemnify and hold harmless the City, its employees and agents, from any and all damages, costs (including, without limitation, legal fees, court costs, and the cost of investigation), judgements or claims by anyone for injury or death of persons resulting from the collapse or failure of trenches constructed under this Contract.

B. Contractor acknowledges and agrees that this indemnity provision provides indemnity for the City in case the City is negligent either by act or omission in providing for trench safety, including, but not limited to safety program and design reviews, inspections, failures to issue stop work orders, and the hiring of the Contractor.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and maintain trench safety systems in accordance with provisions of OSHA 29CFR.

B. Install specially designed trench safety systems in accordance with the Contractor's trench excavation safety program for the locations and conditions identified in the program.

C. A competent person, as identified in the Contractor's Trench Safety Program, shall verify that trench boxes and other premanufactured systems are certified for the actual installation conditions.

3.02 INSPECTION

A. Contractor, or Contractor's independently retained consultant, shall make daily inspections of the trench safety systems to ensure that the installed systems and operations meet OSHA 29CFR and other personnel protection regulations requirements.

B. If evidence of possible cave-ins or slides is apparent, Contractor shall immediately stop work in the trench and move personnel to safe locations until the necessary precautions have been taken by Contractor to safeguard personnel entering the trench.

C. Maintain a permanent record of daily inspections.

3.03 FIELD QUALITY CONTROL

A. Contractor shall verify specific applicability of the selected or specially designed trench safety systems to each field condition encountered on the project.

END OF SECTION

SECTION 02315

ROADWAY EXCAVATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation and compaction of materials for roadways and roadside ditches.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for roadway excavation, with or without subgrade, is on cubic yard basis. Unless specified otherwise under the borrow (off-site) material or embankment fill work item, measurement for payment shall be based on the cut quantity shown on the drawing.

2. No payment will be made for material excavated under the following conditions:

   a. More than 2 feet outside of vertical planes behind back of curbs

   b. For portion within limits of trench for utilities 24-inch and greater constructed by open-cut methods

   c. As indicated otherwise on Drawings.

3. Measurement for the bid item “Regrade Ditches” is on a linear foot basis. No separate payment will be made for reshaping and regrading roadway ditch shoulder slope and side slope adjacent to installed temporary pavement upon removal of temporary pavement.

4. If specified, off-site borrow material including placement and compaction will be paid by final in-place quantity on cubic yard basis.

5. If specified and shown on the drawing, embankment fill including placement and compaction will be paid by final in-place quantity on cubic yard basis.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft^3 (600 kN-m/m^3)).

B. ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

C. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

D. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide topsoil conforming to requirements of Section 02911 - Topsoil.

B. Provide backfill which is excavated material, graded free of roots, lumps greater than 6 inches, rocks larger than 3 inches, organic material, and debris.

C. Provide structural backfill which is select material meeting following requirements:

1. Plasticity index: not less than 12 nor more than 20.

2. Maximum liquid limit: 45

PART 3 EXECUTION

3.01 PREPARATION

A. Identify required lines, levels, and datum. Coordinate with Section 01725 - Field Surveying.

B. Identify and flag surface and aerial utilities.

C. Notify utility companies to remove or relocate utilities.

D. Identify, stake, and flag known utility locations below grade. Make temporary or permanent relocation of underground pipes, ducts, or utilities where indicated on Drawings.

E. Upon discovery of unknown or badly deteriorated utilities, or concealed conditions, discontinue work. Notify Project Manager and obtain instructions before proceeding in such areas.

F. Obtain approval of top soil quality before excavating and stockpiling.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Trees, shrubs, lawns, existing structures, and other features outside of grading limits.

2. Utilities either above or below grade, which are to remain.

3.03 TOPSOIL REMOVAL

A. Strip off topsoil from area to be excavated to minimum depth of 6 inches, unless indicated otherwise on Drawings.

B. Stockpile topsoil in designated location for reuse. Stockpile topsoil to depth not exceeding 8 feet. Cover to protect from erosion.

3.04 SOIL EXCAVATION

A. Excavate to lines and grades shown on Drawings.

B. Remove unsuitable material not meeting specifications. Backfill with embankment materials and compact to requirements of Section 02330 - Embankment.

C. Record location and plug and fill inactive water and oil wells. Conform to Texas Department of Health, Texas Natural Resource Conservation Commission, and Texas Railroad Commission requirements. Notify Project Manager prior to plugging wells.

D. At intersections, grade back at minimum slope of one inch per foot. Produce smooth riding junction with intersecting street. Maintain proper drainage.

E. When area is inadvertently over excavated, fill area in accordance with requirements of Section 02330 - Embankment at no additional cost to City.

F. Remove material not qualified for use and excess soil not being reused from site in accordance with requirements of Section 01576 - Waste Material Disposal.

3.05 COMPACTION

A. Maintain optimum moisture content of subgrade to attain required density.

B. Compact to following minimum densities at moisture content of optimum to 3 percent above optimum as determined by ASTM D 698, unless otherwise indicated on Drawings:

1. Areas under future paving and shoulders: Minimum density of 95 percent of maximum dry density.

2. Other areas: Minimum density of 90 percent of maximum dry density.

3.06 TOLERANCES

A. Top of Compacted Surface: Plus or minus 1/2 inch in cross section, or in 16-foot length.

3.07 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Test and analysis of soil materials will be performed in accordance with ASTM D 4318, ASTM D 2216, and ASTM D 698.

C. Compaction testing will be performed in accordance with ASTM D 698 or ASTM D 6938.

D. A minimum of three tests will be taken for each 1000 linear feet per lane of roadway.

E. When tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at no additional cost to City.

3.08 PROTECTION

A. Prevent erosion at all times. Maintain ditches and cut temporary swales to allow natural drainage in order to avoid damage to roadway. Do not allow water to pond.

B. Distribute construction traffic evenly over compacted areas, where practical, to aid in obtaining uniform compaction. Protect exposed areas having high moisture content from wheel loads that cause rutting.

C. Maintain excavation and embankment areas until start of subsequent work. Repair and recompact slides, washouts, settlements, or areas with loss of density.

END OF SECTION

SECTION 02317

EXCAVATION AND BACKFILL FOR UTILITIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation, trenching, foundation, embedment, and backfill for installation of utilities, including manholes and other pipeline structures.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No additional payment will be made for trench excavation, embedment and backfill under this Section. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

2. When Project Manager directs Contractor to over excavate trench bottom, Contractor will be paid by unit price bid per linear foot under bid item - 6-inches Over Excavation of Trench Bottom.

   a. No payment will be paid if Project Manager does not direct Contractor to over excavate trench bottom.

   b. No over excavation will be measured or paid when unsuitable conditions result from dewatering system not in conformance with Section 01578 - Control of Ground and Surface Water.

3. No additional payment will be made for performing Critical Location exploratory excavation. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price

1.03 DEFINITIONS

A. Pipe Foundation: Suitable and stable native soils that are exposed at trench subgrade after excavation to depth of bottom of bedding as shown on Drawings, or foundation backfill material placed and compacted in over-excavations.

B. Pipe Bedding: Portion of trench backfill that extends vertically from top of foundation up to level line at bottom of pipe, and horizontally from one trench sidewall to opposite sidewall.

C. Haunching: Material placed on either side of pipe from top of bedding up to springline of pipe and horizontally from one trench sidewall to opposite sidewall.

D. Initial Backfill: Portion of trench backfill that extends vertically from springline of pipe (top of haunching) up to level line 12-inches above top of pipe, and horizontally from one trench sidewall to opposite sidewall.

E. Pipe Embedment: Portion of trench backfill that consists of bedding, haunching and initial backfill.

F. Trench Zone: Portion of trench backfill that extends vertically from top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement.

G. Unsuitable Material: Unsuitable soil materials are the following:

1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.

3. Materials that contain large clods, aggregates, stones greater than 4-inches in any dimension, debris, vegetation, waste or any other deleterious materials.

4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

H. Suitable Material: Suitable soil materials are those meeting specification requirements. Materials mixed with lime, fly ash, or cement that can be compacted to required density and meeting requirements for suitable materials may be considered suitable materials, unless otherwise indicated.

I. Backfill: Suitable material meeting specified quality requirements placed and compacted under controlled conditions.

J. Ground Water Control Systems: Installations external to trench, such as well points, eductors, or deep wells. Ground water control includes dewatering to lower ground water, intercepting seepage which would otherwise emerge from side or bottom of trench excavation, and depressurization to prevent failure or heaving of excavation bottom. Refer to Section 01578 - Control of Ground Water and Surface Water.

K. Surface Water Control: Diversion and drainage of surface water runoff and rain water away from trench excavation. Rain water and surface water accidentally entering trench shall be controlled and removed as part of excavation drainage.

L. Excavation Drainage: Removal of surface and seepage water in trench by sump pumping and using drainage layer, as defined in ASTM D 2321, placed on foundation beneath pipe bedding or thickened bedding layer of Class I material.

M. Trench Conditions are defined with regard to stability of trench bottom and trench walls of pipe embedment zone. Maintain trench conditions that provide for effective placement and compaction of embedment material directly on or against undisturbed soils or foundation backfill, except where structural trench support is necessary.

1. Dry Stable Trench: Stable and substantially dry trench conditions exist in pipe embedment zone as result of typically dry soils or achieved by ground water control (dewatering or depressurization) for trenches extending below ground water level.

2. Stable Trench with Seepage: Stable trench in which ground water seepage is controlled by excavation drainage.

    a. Stable Trench with Seepage in Clayey Soils: Excavation drainage is provided in lieu of or to supplement ground water control systems to control seepage and provide stable trench subgrade in predominately clayey soils prior to bedding placement.

    b. Stable Wet Trench in Sandy Soils: Excavation drainage is provided in embedment zone in combination with ground water control in predominately sandy or silty soils.

3. Unstable Trench: Unstable trench conditions exist in pipe embedment zone if ground water inflow or high water content causes soil disturbances, such as sloughing, sliding, boiling, heaving or loss of density.

N. Sub-trench: Sub-trench is special case of benched excavation. Sub-trench excavation below trench shields or shoring installations may be used to allow placement and compaction of foundation or embedment materials directly against undisturbed soils. Depth of sub-trench depends upon trench stability and safety as determined by Contractor.

O. Trench Dam: Placement of low permeability material in pipe embedment zone or foundation to prohibit ground water flow along trench.

P. Over-excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise unsuitable materials below top of foundation as shown on Drawings, and backfilled with foundation bedding.

Q. Foundation Bedding: Natural soil or manufactured aggregate of controlled gradation, and geotextile filter fabrics as required, to control drainage and material separation. Foundation bedding is placed and compacted as backfill to provide stable support for bedding. Foundation bedding materials may include concrete seal slabs.

R. Trench Safety Systems include both protective systems and shoring systems as defined in Section 02260 - Trench Safety Systems.

S. Trench Shield (Trench Box): Portable worker safety structure moved along trench as work proceeds, used as protective system and designed to withstand forces imposed on it by cave

in, thereby protecting persons within trench. Trench shields may be stacked if so designed or placed in series depending on depth and length of excavation to be protected.

T. Shoring System: Structure that supports sides of an excavation to maintain stable soil conditions and prevent cave-ins, or to prevent movement of ground affecting adjacent installations or improvements.

U. Special Shoring: Shoring system meeting special shoring as specified in Paragraph 1.08, Special Shoring Design Requirements, for locations identified on Drawings.

V. Vacuum Excavation: An excavation technique performed by an experienced subcontractor in which water or air jetting is used to slough off and vacuum away soil.

W. Large Diameter Water Line (LDWL): Water line that is 24-inches in diameter or larger. X. Emergency Action Plan (EAP): The EAP document should include a discussion of procedures for timely and reliable detection, classification (level of emergency) and response procedure to a potential emergency condition associated with a large diameter water line.

Y. Subsurface Utility Exploration (SUE): Non-destructive excavation, unless otherwise approved by project manager.

1.04 REFERENCES

A. ASTM A 798 – Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications.

B. ASTM C 12 - Standard Practice for Installing Vitrified Clay Pipe Lines.

C. ASTM C 891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures

D. ASTM C 1479 - Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations

E. ASTM C 1675 - Standard Practice for Installation of Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers

F. ASTM C 1821 - Standard Practice for Installation of Underground Circular Precast Concrete Manhole Structures

G. ASTM D 558 - Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures.

H. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).

I. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.

J. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.

K. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classifications System).

L. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

M. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

N. TxDOT Tex-101-E - Preparing Soil and Flexible Base Materials for Testing.

O. TxDOT Tex-110-E - Particle Size Analysis of Soils.

P. Federal Regulations, 29 CFR Part 1926, Standards-Excavation, Occupational Safety and Health Administration (OSHA).

1.05 SCHEDULING

A. Schedule work so that pipe embedment can be completed on same day that acceptable foundation has been achieved for each section of pipe installation, manhole, or other structures.

B. For proposed utility adjacent to or across existing LDWL:

1. Conduct a meeting between contractor, Drinking Water Operations and Utility Maintenance Branch prior to beginning excavation to coordinate the EAP in the event a water line shut down becomes necessary.

2. Notify Drinking Water Operations a minimum of 1 week prior to beginning construction activities.

3. Notify Drinking Water Operations a minimum of 48 hours prior to beginning SUE work near LDWL.

4. Unless otherwise approved by City Engineer, perform construction activities between 7 AM and 7 PM, Monday through Friday. No work permitted around a LDWL on weekends or City Holiday.

5. A City Inspector must be present during SUE or construction activities occurring within four feet or one diameter of the LDWL, whichever is greater, from a LDWL or appurtenance.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit planned typical method of excavation, backfill placement and compaction including:

1. Trench widths.

2. Procedures for foundation and pipe zone bedding placement, and trench backfill compaction.

3. Procedures for assuring compaction against undisturbed soil when pre-manufactured trench safety systems are proposed.

C. Submit backfill material sources and product quality information in accordance with requirements of Section 02320 - Utility Backfill Materials.

D. Submit trench excavation safety program in accordance with requirements of Section 02260 - Trench Safety System. Include designs for special shoring meeting requirements defined in Paragraph 1.08, Special Shoring Design Requirements contained herein.

E. Submit record of location of utilities as installed, referenced to survey control points. Include locations of utilities encountered or rerouted. Give stations, horizontal dimensions, elevations, inverts, and gradients.

F. Submit 11-inch by 17-inch or 12-inch by 18-inch copy of Drawing with plotted utility or obstruction location titled "Critical Location Report" to Project Manager.

G. For installation of proposed utility adjacent to or across existing LDWL, prepare and submit the following to Drinking Water Operations prior to beginning construction activities. Obtain approval from Drinking Water Operations prior to commencing prelocate or utility work near LDWL.

1. Trench details, shoring system designs, installation sequences, and flowable fill mix designs.

2. Emergency Action Plan (EAP) to address contingency plans in the event of damage to or failure of LDWL. Include the following:

a. Contact personnel and agencies including primary and secondary telephone numbers.

b. Contractor’s hierarchy of responsible personnel.

c. Traffic control measures.

d. Identification of resources to be available on or near project site in event of damage to or failure of LDWL.

1.07 TESTS

A. Testing and analysis of backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by City in accordance with requirements of Section 01454 - Testing Laboratory Services and as specified in this Section.

B. Perform backfill material source qualification testing in accordance with requirements of Section 02320 - Utility Backfill Materials.

1.08 SPECIAL SHORING DESIGN REQUIREMENTS

A. Have special shoring designed or selected by Contractor's Professional Engineer to provide support for sides of excavations, including soils and hydrostatic ground water pressures as applicable, and to prevent ground movements affecting adjacent installations or improvements such as structures, pavements and utilities. Special shoring may be a premanufactured system selected by Contractor's Professional Engineer to meet project site requirements based on manufacturer's standard design.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with hydraulic excavator or other equipment suitable for achieving requirements of this Section.

B. Use only hand-operated tamping equipment until minimum cover of 12-inches is obtained over pipes, conduits, and ducts. Do not use heavy compacting equipment until adequate cover is attained to prevent damage to pipes, conduits, or ducts.

C. Use trench shields or other protective systems or shoring systems which are designed and operated to achieve placement and compaction of backfill directly against undisturbed native soil.

D. Use special shoring systems where required which may consist of braced sheeting, braced soldier piles and lagging, slide rail systems, or other systems meeting requirements as specified in Paragraph 1.08, Special Shoring Design Requirements.

2.02 MATERIAL CLASSIFICATIONS

A. Embedment and Trench Zone Backfill Materials: Conform to classifications and product descriptions of Section 02320 - Utility Backfill Materials and Section 02321 – Cement Stabilized Sand.

B. Concrete Backfill: Conform to requirements for Class B concrete as specified in Section 03315 - Concrete for Utility Construction.

C. Geotextile (Filter Fabric): Conform to requirements of Section 02621 Geotextile.

D. Concrete for Trench Dams: Concrete backfill or 3 sack premixed (bag) concrete.

PART 3 EXECUTION

3.01 STANDARD PRACTICE

A. Install flexible pipe, including "semi-rigid" pipe, to conform to standard practice described in ASTM D 2321, and as described in this Section. Where an apparent conflict occurs between standard practice and requirements of this Section, this Section governs.

B. Install rigid pipe to conform to standard practice described in ASTM C 12, C 1479, or C 1675as applicable, and as described in this Section. Where an apparent conflict occurs between standard practice and requirements of this Section, this Section governs.

3.02 PREPARATION

A. Establish traffic control to conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections affected by Work, and are considered hazardous to traffic movements.

B. Perform work to conform to applicable safety standards and regulations. Employ trench safety system as specified in Section 02260 - Trench Safety Systems.

C. Immediately notify agency or company owning any existing utility line which is damaged, broken, or disturbed. Obtain approval from Project Manager and agency for any repairs or relocations, either temporary or permanent.

D. Remove existing pavements and structures, including sidewalks and driveways, to conform to requirements of Section 02221 - Removing Existing Pavements, Structures, Wood and Demolition Debris, as applicable.

E. Install and operate necessary dewatering and surface-water control measures to conform to Section 01578 - Control of Ground and Surface Water. Provide stable trench to allow installation in accordance with Specifications.

F. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed in writing, replace those which are damaged or destroyed in accordance with Section 01725 - Field Surveying.

3.03 CRITICAL LOCATION INVESTIGATION

A. Horizontal and vertical location of various underground lines shown on Drawings, including but not limited to water lines, gas lines, storm sewers, sanitary sewers, telecommunication lines, electric lines or power ducts, pipelines, concrete and debris, are based on best information available but are only approximate locations. Unless otherwise approved by Project Manager, at Critical Locations shown on Drawings, perform vacuum excavation to field verify horizontal and vertical locations of such lines within a zone 2 feet vertically and 4 feet horizontally of proposed work exclude water jetting at PCCP water line.

1. Verify location of existing utilities minimum of 7 working days in advance of pipe laying activities based on daily pipe laying rate or prior to beginning installation of auger pit or tunnel shaft. Use extreme caution and care when uncovering utilities designated by Critical Locate.

2. Notify Project Manager in writing immediately upon identification of obstruction. In event of failure to identify obstruction in minimum of 7 days, Contractor will not be entitled to extra cost for downtime including, but not limited to, payroll, equipment, overhead, demobilization and remobilization, until 7 days has passed from time Project Manager is notified of obstruction.

B. Notify involved utility companies of date and time that investigation excavation will occur and request that their respective utility lines be marked in field. Comply with utility or pipeline company requirements that their representative be present during excavation. Provide Project Manager with 48 hours notice prior to field excavation or related work.

C. Survey vertical and horizontal locations of obstructions relative to project baseline and datum and plot on 12-inch by 18-inch copy of Drawings. For large diameter water lines, submit to Project Manager for approval, horizontal and vertical alignment dimensions for connections to existing lines, tied into project baseline, signed and sealed by R.P.L.S.

D. LDWL Prelocate Requirements:

1. Field-locate LDWL, appurtenances and laterals connected directly to LDWL through use of non-probing method such as a vacuum truck (non-water jetting method) at no greater than 50-foot intervals. Locate upstream and downstream of proposed work or utility installation.

2. Record crown and side of LDWL adjacent to proposed work or utility installation. Record LDWL locations horizontally and vertically using same coordinate system employed on proposed utility drawings.

3. Tie horizontal and vertical coordinates into project baseline. Submit recordings performed by R.P.L.S to City a minimum of 14 days prior to mobilizing to site.

3.04 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other permanent objects outside of grading limits and within grading limits as designated on Drawings, and in accordance with requirements of Section 01562 - Tree and Plant Protection.

B. Protect and support above-grade and below-grade utilities which are to remain.

C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities is indicated on Drawings.

D. Take measures to minimize erosion of trenches. Do not allow water to pond in trenches. Where slides, washouts, settlements, or areas with loss of density or pavement failures or

potholes occur, repair, re-compact, and pave those areas at no additional cost to City.

E. Contingency plans for proposed work or utility installation adjacent to or across a LDWL:

1. Conduct on-site emergency drill prior to commencing proposed utility installation, and at three month intervals to assure EAP is current.

2. In the event a LDWL shut down becomes necessary, secure site and provide assistance to City personnel to access pipe and isolation valves as needed.

3.05 EXCAVATION

A. Except as otherwise specified or shown on Drawings, install underground utilities in open cut trenches with vertical sides.

B. Perform excavation work so that pipe, conduit, and ducts can be installed to depths and alignments shown on Drawings. Avoid disturbing surrounding ground and existing facilities and improvements.

C. Determine trench excavation widths using following schedule as related to pipe outside diameter (O.D.). Excavate trench so that pipe is centered in trench.

Nominal Pipe Size, Inches	Minimum Trench Width, Inches
Less than 18	O.D. + 18
18 to 30	O.D. + 24
36 to 42	O.D. + 36
Greater than 42	O.D. + 48

Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

D. Use sufficient trench width or benches above embedment zone for installation of well point headers or manifolds and pumps where depth of trench makes it uneconomical or impractical to pump from surface elevation. Provide sufficient space between shoring cross braces to permit equipment operations and handling of forms, pipe, embedment and backfill, and other materials.

E. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify Project Manager and obtain instructions before proceeding.

F. Shoring of Trench Walls.

1. Install Special Shoring in advance of trench excavation or simultaneously with trench excavation, so that soils within full height of trench excavation walls will remain laterally supported at all times.

2. For all types of shoring, support trench walls in pipe embedment zone throughout installation. Provide trench wall supports sufficiently tight to prevent washing trench wall soil out from behind trench wall support.

3. Leave sheeting driven into or below pipe embedment zone in place to preclude loss of support of foundation and embedment materials, unless otherwise directed by Project Manager. Leave rangers, walers, and braces in place as long as required to support sheeting, which has been cut off, and trench wall in vicinity of pipe zone.

4. Employ special methods for maintaining integrity of embedment or foundation material. Before moving supports, place and compact embedment to sufficient depths to provide protection of pipe and stability of trench walls. As supports are moved, finish placing and compacting embedment.

5. If sheeting or other shoring is used below top of pipe embedment zone, do not disturb pipe foundation and embedment materials by subsequent removal. Maximum thickness of removable sheeting extending into embedment zone shall be equivalent of 1-inch-thick steel plate. As sheeting is removed, fill in voids left with grouting material.

G. Use of Trench Shields. When trench shield (trench box) is used as worker safety device, the following requirements apply:

1. Make trench excavations of sufficient width to allow shield to be lifted or pulled freely, without damage to trench sidewalls.

2. Move trench shields so that pipe, and backfill materials, after placement and compaction, are not damaged nor disturbed, nor degree of compaction reduced. Re-compact after shield is moved if soil is disturbed.

3. When required, place, spread, and compact pipe foundation and bedding materials beneath shield. For backfill above bedding, lift shield as each layer of backfill is placed and spread. Place and compact backfill materials against undisturbed trench walls and foundation.

4. Maintain trench shield in position to allow sampling and testing to be performed in safe manner.

5. Conform to applicable Government regulations.

H. Voids under paving area outside shield caused by Contractor's work will require removal of pavement, consolidation and replacement of pavement in accordance with Contract Documents. Repair damage resulting from failure to provide adequate supports.

I. Place sand or soil behind shoring or trench shield to prevent soil outside shoring from collapsing and causing voids under pavement. Immediately pack suitable material in outside voids following excavation to avoid caving of trench walls.

J. Coordinate excavation within 15 feet of pipeline with company's representative. Support pipeline with methods agreed to by pipeline company's representative. Use small, rubber-tired excavator, such as backhoe, to do exploratory excavation. Bucket that is used to dig in close proximity to pipelines shall not have teeth or shall have guard installed over teeth to approximate bucket without teeth. Excavate by hand within 1 foot of Pipeline Company's line. Do not use larger excavation equipment than normally used to dig trench in vicinity of pipeline until pipelines have been uncovered and fully exposed. Do not place large excavation and hauling equipment directly over pipelines unless approved by Pipeline Company's representative.

K. When, during excavation to uncover pipeline company's pipelines, screwed collar or an oxy-acetylene weld is exposed, immediately notify Project Manager. Provide supports for collar or welds. Discuss with Pipeline Company's representative and determine methods of supporting collar or weld during excavation and later backfilling operations. When collar is exposed, request Pipeline Company to provide welder in a timely manner to weld ends of collar prior to backfilling of excavation.

L. Excavation and shoring requirements for proposed work or utility installation adjacent to or across a LDWL:

1. Identify LDWL area in field and barricade off from construction activities. Allow no construction related activities including, but not limited to, loading of dump trucks and material staging or storage, on top of LDWL.

2. Employ a groundwater control system when performing excavation activities within ten feet of LDWL to:

   a. Effectively reduce hydrostatic pressure affecting excavations,

   b. Develop substantially dry and stable subgrade for subsequent construction operations,

   c. Prevent loss of fines, seepage, boils, quick condition or softening of foundation strata, and

   d. Maintain stability of sides and bottom of excavations.

3. When edge of proposed trench or shoring is within a distance equal to one diameter of LDWL from outside of wall of LDWL, valve or appurtenance:

   a. Maintain minimum of four (4) feet horizontal clearance and minimum of two (2) feet vertical clearance between proposed utility and LDWL.

   b. Auger Construction

      1) Maintain minimum of four (4) feet horizontal clearance between proposed utility and LDWL.

2) Dry auger method required when auger hole is 12-inches and larger in diameter.

c. Open Cut Construction and Auger pits

1) Perform hand excavation when within four (4) feet of LDWL.

2) Employ hydraulic or pneumatic shoring system. Do not use vibratory or impact driven shoring or piling.

3) Expose no more than 30-feet of trench prior to backfilling.

4) A maximum of one (1) foot of vertical trench shall be un-braced at a time to maintain constant pressure on face of excavated soil.

5) Upon removal of shoring system, inject flowable fill into void space left behind by shoring system. Comply with Standard Specification 02322 - Flowable Fill.

d. When edge of utility excavation is greater than one diameter of LDWL from outside wall of LDWL, use a shielding system as required by Project Manager and proposed utility standards and practices.

3.06 HANDLING EXCAVATED MATERIALS

A. Use only excavated materials, which are suitable as defined in this Section and conforming to Section 02320 - Utility Backfill Materials. Place material suitable for backfilling in stockpiles at distance from trench to prevent slides or cave-ins.

B. When required, provide additional backfill material conforming to requirements of Section 02320 - Utility Backfill Materials.

C. Do not place stockpiles of excess excavated materials on streets and adjacent properties. Protect backfill material to be used on site. Maintain site conditions in accordance with Section 01504 - Temporary Facilities and Controls. Excavate trench so that pipe is centered in trench. Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

3.07 TRENCH FOUNDATION

A. Excavate bottom of trench to uniform grade to achieve stable trench conditions and satisfactory compaction of foundation or bedding materials.

B. When wet soil is encountered on trench bottom and dewatering system is not required, over excavate an additional 6-inches with approval by Project Manager. Place non-woven geotextile fabric and then compact 12-inches of crushed stone in one lift on top of fabric. Compact crushed stone with four passes of vibratory-type compaction equipment.

C. Perform over excavation, when directed by Project Manager, in accordance with Paragraph 3.07.B above. Removal of unstable or unsuitable material may be required if approved by Project Manager;

1. Even though Contractor has not determined material to be unsuitable, or

2. If unstable trench bottom is encountered and an adequate ground water control system is installed and operating according to Section 01578 - Control of Ground and Surface Water.

D. Place trench dams in Class I foundations in line segments longer than 100 feet between manholes and not less than one in every 500 feet of pipe placed. Install additional dams as needed to achieve workable construction conditions. Do not place trench dams closer than 5 feet from manholes.

3.08 PIPE EMBEDMENT, PLACEMENT, AND COMPACTION

A. Remove loose, sloughing, caving, or otherwise unsuitable soil from bottoms and sidewalls of trenches immediately prior to placement of embedment materials.

B. Place embedment including bedding, haunching, and initial backfill as shown on Drawings.

C. For pipe installation, manually spread embedment materials around pipe to provide uniform bearing and side support when compacted. Protect flexible pipe from damage during placing of pipe zone bedding material. Perform placement and compaction directly against undisturbed soils in trench sidewalls, or against sheeting which is to remain in place.

D. Do not place trench shields or shoring within height of embedment zone unless means to maintain density of compacted embedment material are used. If moveable supports are used in embedment zone, lift supports incrementally to allow placement and compaction of material against undisturbed soil.

E. Place geotextile to prevent particle migration from in-situ soil into open-graded (Class I) embedment materials or drainage layers.

F. Do not damage coatings or wrappings of pipes during backfilling and compacting operations. When embedding coated or wrapped pipes, do not use crushed stone or other sharp, angular aggregates.

G. Place haunching material manually around pipe and compact it to provide uniform bearing and side support. If necessary, hold small-diameter or lightweight pipe in place during compaction of haunch areas and placement beside pipe with sand bags or other suitable means.

H. Place electrical conduit, if used, directly on foundation without bedding.

I. Shovel in-place and compact embedment material using pneumatic tampers in restricted areas, and vibratory-plate compactors or engine-powered jumping jacks in unrestricted areas.

Compact each lift before proceeding with placement of next lift. Water tamping is not allowed.

J. For water lines construction embedment, use bank run sand, concrete sand, gem sand, pea gravel, or crushed limestone as specified in Section 02320 - Utility Backfill Material. Adhere to the following subparagraph numbers 1 and 2.

1. Class I, II and III Embedment Materials:

a. Maximum 6-inches compacted lift thickness.

b. Compact to achieve minimum of 95 percent of maximum dry density as determined according to ASTM D 698.

c. Moisture content to be within -3 percent to +5 percent of optimum as determined according to ASTM D 698, unless otherwise approved by Project Manager.

2. Cement Stabilized Sand (where required for special installations):

a. Maximum 6-inches compacted thickness.

b. Compact to achieve minimum of 95 percent of maximum dry density as determined according to ASTM D 698.

c. Moisture content to be on dry side of optimum as determined according to ASTM D 698 but sufficient for effective hydration.

K. For Sanitary Sewers adhere to subparagraph number 1 and 2. For Storm Sewers provide cement stabilized sand per paragraph 2. This provision does not apply to Storm Sewers constructed of HDPE pipe installed under pavement.

1. Class I Embedment Materials.

a. Maximum 6-inches compacted lift thickness.

b. Systematic compaction by at least two passes of vibrating equipment. Increase compaction effort as necessary to effectively embed pipe to meet deflection test criteria.

c. Moisture content as determined by Contractor for effective compaction without softening soil of trench bottom, foundation or trench walls.

2. Class II Embedment and Cement Stabilized Sand.

a. Maximum 6-inches compacted thickness.

b. Compaction by methods determined by Contractor to achieve minimum of 95

percent of maximum dry density as determined according to ASTM D 698 for Class II materials and according to ASTM D 558 for cement stabilized materials.

c. Moisture content of Class II materials within 3 percent of optimum as determined according to ASTM D 698. Moisture content of cement stabilized sands on dry side of optimum as determined according to ASTM D 558 but sufficient for effective hydration.

L. For Storm Sewers constructed of any flexible pipe product and installed under pavement provide flowable fill pipe embedment as specified in Section 02322 - Flowable Fill.

M. Place trench dams in Class I embedment in line segments longer than 100 feet between manholes, and not less than one in every 500 feet of pipe placed. Install additional dams as needed to achieve workable construction conditions. Do not place trench dams closer than 5 feet from manholes.

3.09 TRENCH ZONE BACKFILL PLACEMENT AND COMPACTION

A. Place backfill for pipe or conduits and restore surface as soon as practicable. Leave only minimum length of trench open as necessary for construction.

B. For water lines, under pavement and to within one foot back of curb, use backfill materials described below:

1. For water lines 20-inches in diameter and smaller, use bank run sand or select backfill materials up to pavement base or subgrade.

2. For water lines 24-inches in diameter and larger, backfill with suitable on-site material (random backfill) up to 12-inches below pavement base or subgrade. Place minimum of 12-inches of select backfill below pavement base or subgrade.

C. For sewer pipes (Storm and Sanitary), use backfill materials described by trench limits. For "trench zone backfill" under pavement and to within one foot back of curb, use cement stabilized sand for pipes of nominal sizes 36-inches in diameter and smaller to level 12 inches below the pavement. For sewer pipes 42-inches in diameter and larger, under pavement or natural ground, backfill from 12-inches above top of pipe to 120 inches below pavement with suitable on-site material or select backfill. Use select backfill for rigid pavements or flexible base material for asphalt pavements for 12-inch backfill directly under pavement. For backfill materials reference Section 02320 - Utility Backfill Materials. This provision does not apply where a Storm Sewer is constructed of any flexible pipe product.

D. For Storm Sewers constructed of any flexible pipe product and installed under pavement provide flowable fill as specified in Section 02322 - Flowable Fill. For Storm Sewers constructed of any flexible pipe product and not installed under pavement provide cement stabilized sand.

E. Where damage to completed pipe installation work is likely to result from withdrawal of

sheeting, leave sheeting in place. Cut off sheeting 1.5-feet or more above crown of pipe. Remove trench supports within 5-feet from ground surface.

F. Unless otherwise shown on Drawings. Use one of the following trench zone backfills under pavement and to within one foot of edge of pavement. Place trench zone backfill in lifts and compact. Fully compact each lift before placement of next lift.

1. Class I, II, or III or combination thereof:

   a. Place in maximum 12-inch thick loose layers.

   b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 698.

   c. Moisture content within zero percent to 5 percent above optimum determined according to ASTM D 698, unless otherwise approved by Project Manager.

2. Cement-Stabilized Sand:

   a. Maximum lift thickness determined by Contractor to achieve uniform placement and required compaction, but do not exceed 12-inches.

   b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 558.

   c. Moisture content on dry side of optimum determined according to ASTM D 558 but sufficient for cement hydration.

3. Class IVA and IVB (Clay Soils):

   a. Place in maximum 8-inch thick loose lifts.

   b. Compaction by vibratory Sheepfoot roller to minimum of 95 percent of maximum dry density determined according to ASTM D 698.

   c. Moisture content within zero percent to 5 percent above optimum determined according to ASTM D 698, unless approved by Project Manager.

G. Unless otherwise shown on Drawings, for trench excavations not under pavement, random backfill of suitable material may be used in trench zone. This provision does not apply to flexible pipe used for storm sewers.

1. Fat clays (CH) may be used as trench zone backfill outside paved areas at Contractor's option. When required density is not achieved, at any additional cost to City, rework, dry out, use lime stabilization or other approved methods to achieve compaction requirements, or use different suitable material.

2. Maximum 9-inch compacted lift thickness for clayey soils and maximum 12-inch lift

thickness for granular soils.

3. Compact to minimum of 90 percent of maximum dry density determined according to ASTM D 698.

4. Moisture content as necessary to achieve density.

H. For electric conduits, remove form work used for construction of conduits before placing trench zone backfill.

3.10 MANHOLES, JUNCTION BOXES AND OTHER PIPELINE STRUCTURES

A. Below paved areas or where shown on Drawings, encapsulate manhole with cement stabilized sand; minimum of 2 foot below base, minimum 2 foot around walls, up to pavement subgrade or natural ground. Compact in accordance with Paragraph 3.09.F.2 of this Section

B. In unpaved areas, use select fill for backfill. Existing material that qualifies as select material may be used, unless indicated otherwise on Drawings. Deposit backfill in uniform layers and compact each layer as specified. Maintain backfill material at no less than 2 percent below nor more than 5 percent above optimum moisture content, unless otherwise approved by Project Manager. Place fill material in uniform 8-inch maximum loose layers. Compact fill to at least 95 percent of maximum Standard Proctor Density according to ASTM D 698.

C. For LDWL projects, encapsulate manhole with cement stabilized sand; minimum of 1 foot below base, minimum of 2 feet around walls, up to within 12-inches of pavement subgrade or natural ground. For manholes over water line, extend encapsulation to bottom of trench. Compact in accordance with Paragraph 3.09 F.2 of this Section.

3.11 FIELD QUALITY CONTROL

A. Test for material source qualifications as defined in Section 02320 - Utility Backfill Materials.

B. Provide excavation and trench safety systems at locations and to depths required for testing and retesting during construction at no additional cost to City.

C. Tests will be performed on minimum of three different samples of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is noticeable change in material gradation or plasticity, or when requested by Project Manager.

D. At least three tests for moisture-density relationships will be performed initially for backfill materials in accordance with ASTM D 698, and for cement- stabilized sand in accordance with ASTM D 558. Perform additional moisture-density relationship tests once a month or whenever there is noticeable change in material gradation or plasticity.

E. In-place density tests of compacted pipe foundation, embedment and trench zone backfill soil materials will be performed according to ASTM D 1556 or ASTM D 6938, and at following frequencies and conditions.

1. For open cut construction projects and auger pits: Unless otherwise approved by Project Manager, successful compaction to be measured by one test per 40 linear feet measured along pipe for compacted embedment and two tests per 40 linear feet measured along pipe for compacted trench zone backfill material. Length of auger pits to be measured to arrive at 40 linear feet.

2. A minimum of three density tests for each full shift of Work.

3. Density tests will be distributed among placement areas. Placement areas are: foundation, outer bedding, haunching, initial backfill and trench zone.

4. The number of tests will be increased if inspection determines that soil type or moisture content are not uniform or if compacting effort is variable and not considered sufficient to attain uniform density, as specified.

5. Density tests may be performed at various depths below fill surface by pit excavation. Material in previously placed lifts may therefore be subject to acceptance/rejection.

6. Two verification tests will be performed adjacent to in-place tests showing density less than acceptance criteria. Placement will be rejected unless both verification tests show acceptable results.

7. Recompacted placement will be retested at same frequency as first test series, including verification tests.

8. Identify elevation of test with respect to natural ground or pavement.

F. Recondition, re-compact, and retest at Contractor's expense if tests indicate Work does not meet specified compaction requirements. For hardened soil cement with nonconforming density, core and test for compressive strength at Contractor's expense.

G. Acceptability of crushed rock compaction will be determined by inspection.

3.12 DISPOSAL OF EXCESS MATERIAL

A. Dispose of excess materials in accordance with requirements of Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02318

EXTRA UNIT PRICE WORK FOR EXCAVATION AND BACKFILL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Measurement and payment applicable to extra unit price work items for excavation and backfill made necessary by unusual or unforeseen circumstances encountered during utility installations.

B. Extra unit price work for excavation and backfill is paid only when authorized in advance by Project Manager.

1.02 MEASUREMENT AND PAYMENT

A. UNIT PRICES

1. Excavation Around Obstructions: Payment for excavation around obstructions is on cubic yard basis, measured in place, without deduction for volume occupied by portions of pipes, ducts, or other structures left in place across trenches excavated under this item.

2. Extra Hand Excavation: Payment for extra hand excavation is on cubic yard basis, measured in place.

3. Extra Machine Excavation: Payment for extra machine excavation is on cubic yard basis, measured in place.

4. Extra Placement of Backfill Material: Payment for extra placement of backfill material is on cubic yard basis, measured in place, for material installed as part of Work. At discretion of Project Manager, measurement of cubic yards may be calculated from volume of Extra Hand Excavation or Extra Machine Excavation for which replacement is made, minus volume of any Extra Placement of Granular Backfill authorized in conjunction with Work.

5. Extra Placement of Granular Backfill: Payment for extra placement of granular backfill material is on cubic yard basis, measured in place.

6. Extra Select Backfill: Payment for extra select backfill is on cubic yard basis, measured in place for a theoretical minimum trench width. The project Manager may authorize extra select backfill when soil from the excavation work does not include adequate quantities for placement of suitable on-site material (random backfill).

7. Refer to Section 01270 – Measurement and payment for unit price procedures.

1.03 DEFINITIONS

A. Excavation Around Obstructions: Excavation necessitated by obstruction of pipes (other than service connections 3 inches in diameter or less), ducts, or other structures, not shown on Drawings, and of an unusual or unforeseen nature which interfere with installation of utility piping by normal methods of excavation or auguring.

B. Extra Hand Excavation: Excavation by manual labor made necessary by unusual or unforeseen circumstances at locations approved in advance by Project Manager.

C. Extra Machine Excavation: Excavation by machine at or near project site to perform related work not included in original project scope but added for convenience of City, as approved in advance by Project Manager.

D. Extra Replacement of Backfill Material: Handling, backfill, and compaction of excavated material authorized under extra work bid items for Extra Hand Excavation or Extra Machine Excavation. Placement and compaction shall conform to requirements specified for excavation and backfill in Sections 02316 – Excavation and Backfill for Structures and 02317 – Excavation and Backfill for Utilities.

E. Extra Placement of Granular Backfill: Hauling, placing, and compacting granular backfill materials as approved by Project Manager in conjunction with Extra Replacement of Backfill Material. Materials placed under this item shall conform to requirements for Bank Run Sand, Cement Stabilized Sand, Concrete Sand, Gem Sand, Crushed Stone, or Crushed Concrete specified for backfill material in Sections 02316 – Excavation and Backfill for Structures and 02317 – Excavation and Backfill for Utilities.

F. Extra Select Backfill: Unsuitable material removed from the project and select backfill material hauled to the project, or conditioning unsuitable material on the site to make it select backfill. Provide select backfill material specified in Section 02320 – Utility Backfill Materials.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 02320

UTILITY BACKFILL MATERIALS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Material Classifications.

B. Utility Backfill Materials:

1. Concrete sand
2. Gem sand
3. Pea gravel
4. Crushed stone
5. Crushed concrete
6. Bank run sand
7. Select backfill
8. Random backfill
9. Cement stabilized sand

C. Material Handling and Quality Control Requirements.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for backfill material. Include payment in unit price for applicable utility installation.
2. Payment for backfill material, when included as separate pay item or when directed by Project Manager, is on cubic yard basis for material placed and compacted within theoretical trench width limits and thickness of material according to Drawings, or as directed by Project Manager.
3. Payment for backfill of authorized over-excavation is in accordance with Section

02318 - Extra Unit Price Work for Excavation and Backfill.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 DEFINITIONS

A. Unsuitable Material:

1. Materials classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.

3. Materials containing large clods, aggregates, or stones greater than 4 inches in any dimension; debris, vegetation, or waste; or any other deleterious materials.

4. Materials contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material:

1. Materials meeting specification requirements.

2. Unsuitable materials meeting specification requirements for suitable soils after treatment with lime or cement.

C. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation backfill material is placed and compacted as backfill where needed to provide stable support for structure foundation base. Foundation backfill materials may include concrete fill and seal slabs.

D. Foundation Base: Crushed stone aggregate with filter fabric as required, cement stabilized sand, or concrete seal slab. Foundation base provides smooth, level working surface for construction of concrete foundation.

E. Backfill Material: Classified soil material meeting specified quality requirements for designated application as embedment or trench zone backfill.

F. Embedment Material: Soil material placed under controlled conditions within embedment zone extending vertically upward from top of foundation to an elevation 12 inches above top of pipe, and including pipe bedding, haunching and initial backfill.

G. Trench Zone Backfill: Classified soil material meeting specified quality requirements and placed under controlled conditions in trench zone from top of embedment zone to base course in paved areas or to surface grading material in unpaved areas.

H. Foundation: Either suitable soil of trench bottom or material placed as backfill of over-excavation for removal and replacement of unsuitable or otherwise unstable soils.

I. Source: Source selected by Contractor for supply of embedment or trench zone backfill material. Selected source may be project excavation, off-site borrow pits, commercial borrow pits, or sand and aggregate production or manufacturing plants.

J. Refer to Section 02317 - Excavation and Backfill for Utilities for other definitions regarding utility installation by trench construction.

1.04 REFERENCES

A. ASTM C 33 - Standard Specification for Concrete Aggregates.

B. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

C. ASTM C 123 - Standard Test Method for Lightweight Particles in Aggregate.

D. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in Los Angeles Machine.

E. ASTM C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

F. ASTM C 142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregates.

G. ASTM D 1140 - Standard Test Methods for Determining the Amount of Material Finer Than 75-µm (No. 200) Sieve in soils by Washing.

H. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

I. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

J. ASTM D 4643 - Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating.

K. TxDOT Tex-110-E - Particle Size Analysis of Soils.

L. TxDOT Tex-460-A - Determining Crushed Face Particle count

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit description of source, material classification and product description, production method, and application of backfill materials.

C. Submit test results for samples of off-site backfill materials. Comply with Paragraph 2.03, Material Testing.

D. Before stockpiling materials, submit copy of approval from landowner for stockpiling backfill material on private property.

E. Provide delivery ticket which includes source location for each delivery of material that is obtained from off-site sources or is being paid as specific bid item.

1.06 TESTS

A. Perform tests of sources for backfill material in accordance with Paragraph 2.03B.

B. Verification tests of backfill materials may be performed by City in accordance with Section 01454 - Testing Laboratory Services and in accordance with Paragraph 3.03.

PART 2 PRODUCTS

2.01 MATERIAL CLASSIFICATIONS

A. Classify materials for backfill for purpose of quality control in accordance with Unified Soil Classification Symbols as defined in ASTM D 2487. Material use and application is defined in utility installation specifications and Drawings either by class, as described in Paragraph 2.01B, or by product descriptions, as given in Paragraph 2.02.

B. Class Designations Based on Laboratory Testing:

1. Class I: Well-graded gravels and sands, gravel-sand mixtures, crushed well-graded rock, little or no fines (GW, SW):

a. Plasticity index: non-plastic.

b. Gradation: D_{60}/D_{10} - greater than 4 percent; amount passing No. 200 sieve - less than or equal to 5 percent.

2. Class II: Poorly graded gravels and sands, silty gravels and sands, little to moderate fines (GM, GP, SP, SM):

a. Plasticity index: non-plastic to 4.

b. Gradations:

1) Gradation (GP, SP): amount passing No. 200 sieve - less than 5 percent.
2) Gradation (GM, SM): amount passing No. 200 sieve - between 12 percent and 50 percent.
3) Borderline gradations with dual classifications (e.g., SP-SM): amount passing No. 200 sieve - between 5 percent and 12 percent.

3. Class III: Clayey gravels and sands, poorly graded mixtures of gravel, sand, silt, and clay (GC, SC, and dual classifications, e.g., SP-SC):

a. Plasticity index: greater than 7.

b. Gradation: amount passing No. 200 sieve - between 12 percent and 50 percent.

4. Class IVA: Lean clays (CL).

a. Plasticity Indexes:
1) Plasticity index: greater than 7, and above A line.
2) Borderline plasticity with dual classifications (CL-ML): PI between 4 and 7.

b. Liquid limit: less than 50.

c. Gradation: amount passing No. 200 sieve - greater than 50 percent.

d. Inorganic.

5. Class IVB: Fat clays (CH)

a. Plasticity index: above A line.

b. Liquid limit: 50 or greater.

c. Gradation: amount passing No. 200 sieve - greater than 50 percent.

d. Inorganic.

6. Use soils with dual class designation according to ASTM D 2487, and which are not defined above, according to more restrictive class.

2.02 PRODUCT DESCRIPTIONS

A. Soils classified as silt (ML) silty clay (CL-ML with PI of 4 to 7), elastic silt (MH), organic clay and organic silt (OL, OH), and organic matter (PT) are not acceptable as backfill

materials. These soils may be used for site grading and restoration in unimproved areas as approved by Project Manager. Soils in Class IVB, fat clay (CH) may be used as backfill materials where allowed by applicable backfill installation specification. Refer to Section 02316 - Excavation and Backfill for Structures and Section 02317 - Excavation and Backfill for Utilities.

B. Provide backfill material that is free of stones greater than 6 inches, free of roots, waste, debris, trash, organic material, unstable material, non-soil matter, hydrocarbon or other contamination, conforming to following limits for deleterious materials:

1. Clay lumps: Less than 0.5 percent for Class I, and less than 2.0 percent for Class II, when tested in accordance with ASTM C 142.

2. Lightweight pieces: Less than 5 percent when tested in accordance with ASTM C 123.

3. Organic impurities: No color darker than standard color when tested in accordance with ASTM C 40.

C. Manufactured materials, such as crushed concrete, may be substituted for natural soil or rock products where indicated in product specification, and approved by Project Manager, provided that physical property criteria are determined to be satisfactory by testing.

D. Bank Run Sand: Durable bank run sand classified as SP, SW, or SM by Unified Soil Classification System (ASTM D 2487) meeting following requirements:

1. Less than 15 percent passing number 200 sieve when tested in accordance with ASTM D 1140. Amount of clay lumps or balls may not exceed 2 percent.

2. Material passing number 40 sieve shall meet the following requirements when tested in accordance with ASTM D 4318: Plasticity index: not exceeding 7.

E. Concrete Sand: Natural sand, manufactured sand, or combination of natural and manufactured sand conforming to requirements of ASTM C 33 and graded within following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8"	100
No. 4	95 to 100
No. 8	80 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	10 to 30
No. 100	2 to 10

F. Gem Sand: Sand conforming to requirements of ASTM C 33 for course aggregates specified for number 8 size and graded within the following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8”	95 to 100
No. 4	60 to 80
No. 8	15 to 40

G. Pea Gravel: Durable particles composed of small, smooth, rounded stones or pebbles and graded within the following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
1/2”	100
3/8”	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

H. Crushed Aggregates: Crushed aggregates consist of durable particles obtained from an approved source and meeting the following requirements:

1. Materials of one product delivered for same construction activity from single source, unless otherwise approved by Project Manager.

2. Non-plastic fines.

3. Los Angeles abrasion test wear not exceeding 45 percent when tested in accordance with ASTM C 131.

4. Crushed aggregate shall have minimum of 90 percent of particles retained on No. 4 sieve with 2 or more crushed faces as determined by Tex-460-A, Part I.

5. Crushed stone: Produced from oversize plant processed stone or gravel, sized by crushing to predominantly angular particles from naturally occurring single source. Uncrushed gravel is not acceptable materials for embedment where crushed stone is shown on applicable utility embedment drawing details.

6. Crushed Concrete: Crushed concrete is an acceptable substitute for crushed stone as utility backfill. Gradation and quality control test requirements are same as crushed stone. Provide crushed concrete produced from normal weight concrete of uniform quality; containing particles of aggregate and cement material, free from other

substances such as asphalt, reinforcing steel fragments, soil, waste gypsum (calcium sulfate), or debris.

7. Gradations, as determined in accordance with Tex-110-E.

Sieve	Percent Passing by Weight for Pipe Embedment by Ranges of Nominal Pipes Sizes		
	>15"	15" - 8"	<8"
1"	95 - 100	100	-
3/4"	60 - 90	90 - 100	100
1/2"	25 - 60	-	90 - 100
3/8"	-	20 - 55	40 - 70
No. 4	0 - 5	0 - 10	0 - 15
No. 8	-	0 - 5	0 - 5

I. Select Backfill: Class III clayey gravel or sand or Class IV lean clay with plasticity index between 7 and 20 or clayey soils treated with lime in accordance with Section 02951 - Pavement Repair and Restoration to meet plasticity criteria.

J. Random Backfill: Any suitable soil or mixture of soils within Classes I, II, III and IV; or fat clay (CH) where allowed by applicable backfill installation specification. Refer to Section 02316 - Excavation and Backfill for Structures and Section 02317 - Excavation and Backfill for Utilities.

K. Cement Stabilized Sand: Conform to requirements of Section 02321 - Cement Stabilized Sand.

L. Concrete Backfill: Conform to Class B concrete as specified in Section 03315 - Concrete for Utility Construction.

M. Flexible Base Course Material: Conform to requirements of applicable portions of Section 02711 - Hot Mix Asphaltic Base Course, Section 02712 - Cement Stabilized Base Course, and Section 02713 - Recycled Crushed Concrete Base Course.

2.03 MATERIAL TESTING

A. Source Qualification. Perform testing to obtain tests by suppliers for selection of material sources and products not from the project site. Test samples of processed materials from current production representing material to be delivered. Use tests to verify that materials meet specification requirements. Repeat qualification test procedures each time source characteristics change or there is planned change in source location or supplier. Include the following qualification tests, as applicable:

1. Gradation. Report complete sieve analyses regardless of specified control sieves from largest particle through No. 200 sieve.

2. Plasticity of material passing No. 40 sieve

3. Los Angeles abrasion wear of material retained on No. 4 sieve

4. Clay lumps

5. Lightweight pieces

6. Organic impurities

B. Production Testing. Provide reports to Project Manager from an independent testing laboratory that backfill materials to be placed in Work meet applicable specification requirements.

C. Assist Project Manager in obtaining material samples for verification testing at source or at production plant.

PART 3 EXECUTION

3.01 SOURCES

A. Use of existing material in trench excavations is acceptable, provided applicable specification requirements are satisfied.

B. Identify off-site sources for backfill materials at least 14 days ahead of intended use so that Project Manager may obtain samples for verification testing.

C. Materials may be subjected to inspection or additional verification testing after delivery. Materials which do not meet requirements of specifications will be rejected. Do not use material which, after approval, has become unsuitable for use due to segregation, mixing with other materials, or by contamination. Once material is approved by Project Manager, expense for sampling and testing required to change to different material will be credited to City through change order.

D. Bank run sand, select backfill, and random backfill, if available in project excavation, may be obtained by selective excavation and acceptance testing. Obtain additional quantities of these materials and other materials required to complete work from off-site sources.

E. City does not represent or guarantee that any soil found in excavation work will be suitable and acceptable as backfill material.

3.02 MATERIAL HANDLING

A. When backfill material is obtained from either commercial or non-commercial borrow pit, open pit to expose vertical faces of various strata for identification and selection of approved material to be used. Excavate selected material by vertical cuts extending through exposed strata to achieve uniformity in product.

B. Establish temporary stockpile locations for practical material handling, control, and verification testing by Project Manager in advance of final placement. Obtain approval from landowner for storage of backfill material on adjacent private property.

C. When stockpiling backfill material near project site, use appropriate covers to eliminate blowing of materials into adjacent areas and prevent runoff containing sediments from entering drainage system.

D. Place stockpiles in layers to avoid segregation of processed materials. Load material by making successive vertical cuts through entire depth of stockpile.

3.03 FIELD QUALITY CONTROL

A. Quality Control

1. The Project Manager may sample and test backfill at:

   a. Sources including borrow pits, production plants and Contractor's designated off-site stockpiles.

   b. On-site stockpiles.

   c. Materials placed in Work.

2. The Project Manager may re-sample material at any stage of work or location if changes in characteristics are apparent.

B. Production Verification Testing: City's testing laboratory will provide verification testing on backfill materials, as directed by Project Manager. Samples may be taken at source or at production plant, as applicable.

END OF SECTION

SECTION 02330

EMBANKMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of embankments with excess excavated material and borrow.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for embankment under this section. Include payment in unit price for excavation or borrow.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).

B. ASTM D 6938 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

PART 2 PRODUCTS

2.01 MATERIALS

A. Refer to Section 02315 - Roadway Excavation for acceptable excess materials from roadway excavation.

B. Refer to Section 02317 - Excavation and Backfill For Utilities for acceptable excess materials from utility excavation and trenching.

C. Refer to Section 02319 - Borrow for acceptable borrow materials.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify borrow and excess excavated materials to be reused are approved.

B. Verify removals and clearing and grubbing operations have been completed.

3.02 PREPARATION

A. Backfill test pits, stump holes, small swales and other surface irregularities. Backfill and compact in designated lift depths to requirements for embankment compaction.

B. Record location and plug and fill inactive water and oil wells. Conform to Texas State Health Department, Texas Commission on Environmental Quality and Texas Railroad Commission requirements. Notify City Engineer prior to plugging wells.

C. Excavate and dispose of unsuitable soil and other unsuitable materials which will not consolidate. Backfill and compact to requirements for embankment. Unsuitable soil is defined in Section 02316 - Excavation and Backfill for Structures and Section 02320 - Utility Backfill Materials.

D. Backfill new utilities below future grade. Conform to requirements of Sections 02317 - Excavation and Backfill For Utilities, 02511 - Water Lines, 02531 - Gravity Sanitary Sewers, and 02532 - Sanitary Sewer Force Mains.

3.03 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other features outside of embankment limits.

B. Protect utilities above and below grade, which are to remain.

C. Conform to protection requirements of Section 02315 - Roadway Excavation.

3.04 PLACING EMBANKMENT

A. Do not conduct placement operations during inclement weather or when existing ground or fill materials exceed 3 percent of optimum moisture content. Contractor may manipulate wet material to facilitate drying, by disking or windrowing.

B. Do not place embankment fill until density and moisture content of previously placed material comply with specified requirements.

C. Scarify areas to be filled to minimum depth of 4 inches to bond existing and new materials. Mix with first fill layer.

D. Spread fill material evenly, from dumped piles or windrows, into horizontal layers

approximately parallel to finished grade. Place to meet specified compacted thickness. Break clods and lumps and mix materials by blading, harrowing, disking or other approved method. Extend each layer across full width of fill.

E. Each layer shall be homogeneous and contain uniform moisture content before compaction. Mix dissimilar abutting materials to prevent abrupt changes in composition of fill.

F. Layers shall not exceed the following compacted thickness:

1. Areas indicated to be under future paving or shoulders, to be constructed within 6 months: 6 inches when compacted with pneumatic rollers, or 8 inches when compacted with other rollers.

2. Other areas: 12 inches

G. For steep slopes, cut benches into slope and scarify before placing fill. Place increasingly wider horizontal layers of specified depth to level of each bench.

H. Build embankment layers on back slopes, adjacent to existing roadbeds, to level of old roadbed. Scarify top of old roadbed to minimum depth of 4 inches and recompact with next fill layer.

I. Construct to lines and grades shown on Drawings.

J. Remove unsuitable material and excess soil not being used for embankment from site in accordance with requirements of Section 01576 - Waste Material Disposal.

K. Maintain moisture content of embankment materials to attain required density.

L. Compact to following minimum densities at moisture content of optimum to 3 percent above optimum as determined by ASTM D 698, unless otherwise indicated on Drawings:

1. Areas under future paving and shoulders: Minimum density of 95 percent of maximum dry density.

2. Other areas: Minimum density of 90 percent of maximum dry density.

3.06 TOLERANCES

A. Top of compacted surface: Plus or minus 1/2 inch in cross section or 16 foot length.

3.07 FIELD QUALITY CONTROL

A. Compaction Testing will be performed in accordance with ASTM D 698 or ASTM D 6938 under provisions of Section 01454 - Testing Laboratory Services.

B. A minimum of three tests will be taken for each 1000 linear feet per lane of roadway or 500 square yards of embankment per lift.

C. If tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at no cost to City.

END OF SECTION

SECTION 02336

LIME STABILIZED SUBGRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of lime stabilized subgrade material.

1. Application of lime slurry to subgrade.

2. Mixing, compaction, and curing of lime slurry, water, and subgrade into a stabilized foundation.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement and payment for lime stabilized subgrade is on a square yard basis compacted in place to proper density. Separate measurement will be made for each required thickness of subgrade course.

a. Limits of measurement shall match actual pavement replaced, but no greater than maximum pavement replacement limits shown on Drawings. Limits for measurement will be extended to include installed lime stabilized subgrade material that extends 2 foot beyond outside edge of pavement to be replaced, except where proposed pavement section shares common longitudinal or transverse edge with existing pavement section. No payment will be made for lime stabilized subgrade in areas beyond these limits.

b. Limits of measurement and payment shall match pavement replacement limits shown on Drawings, except as noted in Paragraph 1.02.A.1.a, or as approved by Project Manager.

2. Measurement and payment for lime is by ton of 2000 pounds dry weight basis. Calculate weight of dry solids for lime slurry based on percentage by dry weight solids.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 DEFINITION

A. Moist Cure: Curing soil and lime to obtain optimum hydration.

B. 1000-Foot Roadway Section: 1000 feet per lane width or approximately 500 square yards of compacted subgrade for other than full-lane-width roadway sections.

1.04 REFERENCES

A. ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3).

B. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

C. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. TxDOT Tex-101-E (Part III) - Preparing Soil and Flexible Base Materials for Testing.

E. TxDOT Tex-140-E - Measuring Thickness of Pavement Layer.

F. TxDOT Tex-600-J - Sampling and Testing Hydrated Lime, Quicklime, and Commercial Lime Slurry.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification that hydrated lime, quicklime, or commercial lime slurry complies with specifications.

C. Submit weight tickets, certified by supplier, with each bulk delivery of lime to work site.

1.06 DELIVERY, STORAGE AND HANDLING

A. Bagged lime shall bear manufacturer's name, product identification, and certified weight. Bags varying more than 5 percent of certified weight may be rejected; average weight of 50 random bags in each shipment shall not be less than certified weight.

B. Store lime in weatherproof enclosures. Protect lime from ground dampness.

PART 2 PRODUCTS

2.01 WATER

A. Use clean, clear water, free from oil, acids, alkali, or vegetation.

2.02 LIME

A. Type A - Hydrated Lime: Dry material consisting essentially of calcium hydroxide or mixture of calcium hydroxide and an allowable percentage of calcium oxide as listed in chemical composition chart.

B. Type B - Commercial Lime Slurry: Liquid mixture consisting essentially of lime solids and water in slurry form. Water or liquid portion shall not contain dissolved material in sufficient quantity to be injurious or objectionable for purpose intended.

C. Type C - Quicklime: Dry material consisting essentially of calcium oxide. Furnish quicklime in either of the following grades:

1. Grade DS: Pebble quicklime of gradation suitable for use in preparation of slurry for wet placing.

2. Grade S: Finely-graded quicklime for use in preparation of slurry for wet placing. Donor use grade S quicklime for dry placing.

D. Conform to the following requirements:

CHEMICAL COMPOSITION	TYPE		
	A	B	C
Active lime content, % by weight $Ca(OH)_2$+CaO	90.0 min[1]	87.0 min[2]	-
Unhydrated lime content, % by weight CaO	5.0 max	-	87.0 min
Free water content, % by weight H_2O :	5.0 max	-	-
SIZING			
Wet Sieve, as % by weight residue retained:			
No. 6	0.2 max	0.2 max[2]	8.0 max[3]
No. 30	4.0 max	4.0 max[2]	-
Dry sieve, as % by weight residue retained:			
1-inch	-	-	0.0
1/2-inch	-	-	10.0 max

Notes:
1. Maximum 5.0% by weight CaO shall be allowed in determining total active lime content.
2. Maximum solids content of slurry.
3. Total active lime content, as CaO, in material retained on No. 6 sieve shall not exceed 2.0% by weight of original Type C lime.

E. Deliver lime slurry to job site as commercial lime, or prepare at job site by using hydrated lime or quicklime. Provide slurry free of liquids other than water and of consistency that can be handled and uniformly applied without difficulty.

F. Lime containing magnesium hydroxide is prohibited.

2.02 SOIL

A. Soil to receive lime treatment may include borrow or existing subgrade material, existing pavement structure, or combination of all three. Where existing pavement or base material is encountered, pulverized or scarify material so that 100 percent of sampled material passes 2-inch sieve.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted subgrade will support imposed loads.

B. Verify subgrade lines and grades.

3.02 PREPARATION

A. Complete backfill of utilities prior to stabilization.

B. Cut material to bottom of subgrade using an approved cutting and pulverizing machine meeting following requirements:

1. Cutters accurately provide smooth surface over entire width of cut to plane of secondary grade.

2. Provide cut to depth as specified or shown in the Drawings.

C. Alternatively, scarify or excavate to bottom of stabilized subgrade. Remove material or windrow to expose secondary grade. Obtain uniform stability.

D. Correct wet or unstable material below secondary grade by scarifying, adding lime, and compacting as directed by Project Manager.

E. Pulverize existing material so that 100 percent passes a 1-3/4-inch sieve.

3.03 LIME SLURRY APPLICATION

A. Apply slurry with distributor truck equipped with an agitator to keep lime and water in consistent mixture. Make successive passes over measured section of roadway to attain proper moisture and lime content. Limit spreading to an area where preliminary mixing operations can be completed on same working day.

B. Minimum lime content shall be 5 percent of dry unit weight of subgrade as determined by ASTM D 698

3.04 PRELIMINARY MIXING

A. Use approved single-pass or multiple-pass rotary speed mixers to mix soil, lime, and water to required depth. Obtain homogeneous friable mixture free of clods and lumps.

B. Shape mixed subgrade to final lines and grades.

C. Eliminate following operations and final mixing if pulverization requirements of Paragraph 3.05C can be met during preliminary mixing:

1. Seal subgrade as precaution against heavy rainfall by rolling lightly with light pneumatic rollers.

2. Cure soil lime material for 24 to 72 hours or as required to obtain optimum hydration. Keep subgrade moist during cure.

3.05 FINAL MIXING

A. Use approved single-pass or multiple-pass rotary speed mixers to uniformly mix cured soil and lime to required depth.

B. Add water to bring moisture content of soil mixture to optimum or above.

C. Mix and pulverize until all material passes 1-3/4-inch sieve; minimum of 85 percent, excluding non-slacking fractions, passes 3/4-inch sieve; and minimum of 60 percent excluding non-slacking fractions passes No. 4 sieve. Test according to TxDOT Tex-101-E, Part III using dry method.

D. Shape mixed subgrade to final lines and grades.

E. Do not expose hydrated lime to open air for 6 hours or more during interval between application and mixing. Avoid excessive hydrated lime loss due to washing or blowing.

3.06 COMPACTION

A. Aerate or sprinkle to attain optimum moisture content to 3 percent above optimum, as determined by ASTM D 698 on material sample from roadway after final mix with lime.

B. Start compaction immediately after final mixing.

C. Spread and compact in two or more equal layers where total compacted thickness is greater than equipment manufacturer’s recommended range of mixing and compaction.

D. Compact with approved heavy pneumatic or vibrating rollers, or combination of tamping rollers and light pneumatic rollers. Begin compaction at bottom and continue until entire depth is uniformly compacted.

E. Do not allow stabilized subgrade to mix with underlying material. Correct irregularities or weak spots immediately by replacing material and recompacting.

F. Compact subgrade to minimum density of 95 percent of maximum dry density, according to ASTM D 698, at moisture content of optimum to 3 percent above optimum, unless otherwise indicated on Drawings:

G. Seal with approved light pneumatic tired rollers. Prevent surface hair line cracking. Rework and recompact at areas where hairline cracking develops.

3.07 CURING

A. Moist cure for minimum of 3 days before placing base or surface course, or opening to traffic. Subgrade may be opened to traffic after 2 days when adequate strength has been attained to prevent damage. Restrict traffic to light pneumatic rollers or vehicles weighing less than 10 tons.

B. Keep subgrade surface damp by sprinkling. Roll with light pneumatic roller to keep surface knit together.

C. Place base or surface within 14 days after final mixing and compaction. Restart compaction and moisture content of base material when time is exceeded.

3.08 TOLERANCES

A. Completed surface: smooth and conforming to typical section and established lines and grades.

B. Top of compacted surface: Plus or minus 1/4 inch in cross section or in 16-foot length.

C. Depth of lime stabilization shall be plus or minus one inch of specified depth for each 1000-foot roadway section.

3.09 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Test soils, lime, and mixtures as follows:

1. Tests and analysis of soil materials will be performed in accordance with ASTM D 4318, using the wet preparation method.

2. Sampling and testing of lime slurry shall be in accordance with TxDOT Tex-600-J, except using a lime slurry cup.

3. Sample mixtures of hydrated lime or quicklime in slurry form will be tested to establish compliance with specifications.

4. Moisture-density relationship will be established on material sampled from roadway, after stabilization with lime and final mixing, in accordance with ASTM 698, Moist preparation Method.

C. In-place depth will be evaluated for each 1000-foot roadway section and determined in accordance with TxDOT Tex-140-E in hand excavated holes. For each 1000-foot section, 3

phenolphthalein tests will be performed. Average stabilization depth for 1000-foot section will be based on average depth for three tests.

D. Perform compaction testing in accordance with ASTM D 6938. Three tests will be performed for each 1000-foot roadway section.

E. Pulverization analysis will be performed as required by Paragraph 3.05C on material sampled during mixing of each production area. Three tests will be performed per 1000-foot roadway section or a minimum of once daily.

3.10 REWORK OF FAILED SECTIONS

A. Rework sections that do not meet specified thickness.

B. Perform the following steps when more than 72 hours have lapsed since completion of compaction.

1. Moist cure for minimum of 3 days after compaction to required density.

2. Add lime at rate of 25 percent of specified rate at no additional cost to City.

3. Moisture density test of reworked material must be completed by laboratory before field compaction testing can be completed.

3.11 PROTECTION

A. Maintain stabilized subgrade to lines and grades and in good condition until placement of base or surface course. Protect asphalt membrane from being picked up by traffic.

B. Repair defects immediately by replacing material to full depth.

END OF SECTION

SECTION 02582

TRAFFIC SIGNAL POLE ASSEMBLIES - STEEL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Steel traffic signal pole assemblies, including anchor bolts.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Traffic Signal Pole Assemblies will be measured by each traffic signal pole assembly.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Traffic Signal Pole Assemblies (Steel)", of the various types and sizes as specified.

1.03 REFERENCES

A. Reference standards applicable to this section:

1. AASHTO: American Association of State Highway Transportation Officials

a. LTS-1: Structural Supports for Highway Signs, Luminaires and Traffic Signals

2. AISC: American Institute of Steel Construction

3. AISI: American Iron and Steel Institute

4. ASTM: American Society for Testing Materials

a. A36: Standard Specification for Carbon Structural Steel

b. A123: Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

c. A153: Zinc Coating (Hot-Dip) on Iron and Steel Hardware

d. A501: Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

e. A563: Carbon and Alloy Steel Nuts

f. A572: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Steel

g. A595: Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use

h. A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

i. F1554: Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

j. F3125 - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

PART 2 PRODUCTS

2.01 MATERIALS

A. All items shall be new materials of the latest product in production to the commercial trade and shall be of the highest quality as to materials used and workmanship. The manufacturer of these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items, which have been in successful operation, for not less than three (3) years.

2.02 SILENCE OF SPECIFICATIONS

A. The apparent silence of these specifications as to any detail, or the apparent omission from it of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice shall prevail and that only material and workmanship of the finest quality shall be used. All interpretations of these specifications shall be made on the basis of this statement.

2.03 TRAFFIC SIGNAL POLE ASSEMBLIES

A. The traffic signal poles shall be designed in accordance with the latest edition of the AASHTO standard specifications.

B. Anchorage: Included with each pole shall be a minimum of four steel anchor bolts, complete with double hex nuts, lock washers and flat washers. Nuts, washers and threaded areas of anchor bolts shall be hot-dip galvanized to ASTM - A153. Anchor bolts shall meet the requirements of ASTM F1554, Gr. 55. An anchor bolt template shall be included with each pole assembly.

C. Wind Resistance: Entire pole and arm assembly to be rated to withstand AASHTO requirements for 90 mile per hour wind.

D. Welds: All welds shall meet the requirements of AWS D1.1.

E. Material Certification: Material certifications shall be provided for all ASTM numbers referred to in this specification.

F. Complete design drawings and complete technical data must be submitted for approval to the City of Houston prior to starting fabrication. Shop drawings shall be signed and sealed by a Registered Professional Engineer.

G. The pole unit and all materials used in its manufacture shall meet the requirements of the American Association of State Highway and Transportation Officials (AASHTO), specifically LTS-1: Standard Specifications of Structural Supports for Highway Signs, Luminaries and Traffic Signals.

H. Pole shaft and arms shall be circular or octagonal in cross-section with no transverse joints or welds and no more than one (1) longitudinal welds per pole or arm. Refer to the standard drawings for exact sizes on the pole diameters. They shall be uniform in cross-section and shall uniformly taper from the pole shaft to the end of the arm. The end of the arm shall be at a height above the pavement, as detailed on the standard drawing, with design vertical loadings, when installed on the pole.

2.04 POLE SHAFT

A. The pole shaft for the Type 1 poles shall be fabricated from a minimum of 3-gauge (0.2391 inch) hot rolled commercial steel. The shaft shall have only one (1) longitudinal, automatically, electrically welded joint, and shall have no intermediate horizontal joints nor welds. After forming and welding, the tapered shaft shall be longitudinally cold rolled over a hardened steel mandrel under sufficient hydraulic pressure to flatten the weld and increase the physical characteristics of the shaft. The shaft shall meet the chemical and physical properties of ASTM-A595 GR. A, having a minimum yield strength of 55,000 psi. Only one length of steel sheet shall be used, which shall be formed into a continuously tapered shaft, having a taper of approximately 0.14 inch per foot.

B. The pole shaft for the Type 2 poles shall be fabricated from a minimum 0.375 inch hot rolled commercial steel. The shaft shall have only one (1) longitudinal, automatically, electrically welded joint, and shall have no intermediate horizontal joints nor welds. The shaft shall meet the chemical and physical properties of ASTM-A572 GR. 55, having a minimum yield strength of 55,000 psi. Only one (1) length of steel sheet shall be used, which shall be formed into a continuously tapered shaft, having a taper of approximately 0.14 inch per foot.

C. The base plate shall conform to ASTM-A36 or ASTM A572 steel. It shall telescope the shaft and be attached by means of two continuous welds, one on the inside of the base at the end of the shaft, the other on the outside at the top of base. The base plate shall be

arranged to accept four (4) 2-1/4 inch diameter anchor bolts on an 18 inch bolt circle.

D. The pole shaft shall be furnished with a reinforced handhole frame with steel cover and a 1/2 inch - 13 UNC grounding provision. Dimensions shall be as shown on the detail drawings.

E. Each pole shaft shall include a steel pole plate welded to shaft for the mast arm connection. It shall be arranged to accept four (4) connecting bolts. Pole plate material shall conform to the requirements of ASTM-A36 or ASTM A572 Grade 50 steel.

F. As required, each pole shall be provided with an ornamental pole top. The final shaped pole top shall be mechanically attached to the top of the shaft to provide access for wiring signals secured by a J-hook wire support; also provided. Pole top material shall conform to the requirements of AA-319.OF aluminum.

G. The pole shaft shall be drilled in the field at required signal locations.

2.05 MAST ARM

A. The mast arm shall be fabricated from a minimum 7-gauge (0.179 inch) hot rolled commercial steel in accordance with ASTM A595 Grade A and shall have a yield of not less than 55,000 psi. It shall be fabricated and formed into a round shape as required, using the same cold rolling process as the pole shaft and shall have the same physical properties and yield strength. Arm dimensions shall be equivalent in strength for the loads shown in the plans.

B. Mast arm shall be a straight flange plate mounted style and shall include a steel arm plate with four (4) connecting bolts. Arm plate material shall conform to the requirements of ASTM-A36 or ASTM A572 Grade 42 steel. Bolts shall be internally mounted to pole plate and meet the requirements of ASTM-F3125.

C. A slip joint shall be permissible for arms forty (40) feet and greater in length. The slip joint shall be made in the shop but may be match marked and shipped disassembled. An automatic submerged arc process shall weld pole shaft and arm. Pole and arm diameters shall be uniform at any cross-section and shall be reasonably straight.

D. Tenons for mounting the vehicle signal head assemblies shall be provided on the mast arm at locations required. Refer to the standard drawings for tenon details.

2.06 LUMINAIRE ARM

A. The luminaire arm shall be fabricated from 2-inch Schedule 80 pipe.

B. The length of the luminaire arm shall be as shown in the standard drawings or required in the plans.

C. The luminaire arm shall be connected to the pole shaft with simplex fittings, and in accordance with details shown on the standard drawings.

2.07 HOT-DIP GALVANIZING

A. Surface Preparation.

1. Prior to being incorporated into an assembled product, steel plates 3/4 inch or more in thickness may require blast cleaning to remove rolled-in mill scale, impurities, and non-metallic foreign materials. After assembly, all weld flux shall be mechanically removed.

2. The iron or steel product is degreased by immersion in an agitated 4.5%-6% concentrated caustic solution elevated to a temperature ranging from 150 to 190-degrees Fahrenheit. It is then pickled by immersion in a heated sulfuric acid solution of 6%-13% concentration, controlling the temperature between 150 and 190-degrees Fahrenheit. It is next rinsed clean from any residual effects of the caustic or acid solutions by immersion in a circulating fresh water bath.

3. Final preparation is done by immersion in a concentrated zinc ammonium chloride flux solution heated to 130-degrees Fahrenheit. The solution's acidity content is maintained between 4.5-5.0 pH. The assembly is air dried to remove any moisture remaining in the flux coat and/or trapped within the product.

B. Pole shaft and arm shall be hot-dip galvanized after fabrication in conformance with ASTM A123 requirements, with a minimum of two (2) ounces per square foot of galvanized coating.

C. All ancillary parts for pole structures shall be hot-dip galvanized after fabrication in conformance with ASTM A153 requirements. The galvanized coating shall be a minimum thickness of two (2) ounces per square foot. All threaded material shall be brushed or retapped after galvanizing. Fabricated products shall be free and clear of teardrop edges, flaking zinc, rough appearance, holes covered with zinc membrane, and similar unattractive finishes. In general, the complete product shall be smooth, clean and unscarred when delivered. Any part of the structures not meeting these requirements shall be rejected.

2.08 POWDER COATING OVER GALVANIZING

A. Surface Preparation. The pole shaft, arm and ancillary parts shall be prepared in accordance with the hot-dip galvanizing requirements of Part 2.06 in this section.

B. Top Coat. All galvanized exterior surfaces visually exposed are to be coated with a Urethane or Triglycidyl Isocyanurate (TGIC) Polyester Powder to a minimum film thickness of 2.0 mils. The galvanized exterior should be etched, preheated, then powder coated. The coating shall be electrostatically applied and cured in a gas-fired convection oven by heating the steel substrate to a minimum of 350-degrees Fahrenheit and a maximum of 400-degrees Fahrenheit.

C. Packaging. In order to protect the finish during transportation, a wrapping of 3/16" U.V. inhibited plastic-backed packing foam must be applied prior to shipment of small poles. Larger poles are cradled in a 1-inch rubberized foam base. A nylon ripcord shall be placed beneath the wrapping the entire length of the pole for removal of the wrapping without the use of knives or any other sharp instrument that maydamage the painted surface.

2.09 SUBMITTALS

A. The Contractor shall furnish mill test report(s) on steel used in pole fabrication. The mill test report(s) shall be furnished prior to or at the time of pole delivery

B. Six (6) copies of shop drawings shall be furnished for City of Houston review and approval prior to pole fabrication.

C. Two (2) copies of shop drawings shall be returned by City of Houston to the manufacturer for its files.

PART 3 EXECUTION – Not Used

END OF SECTION

SECTION 02631

STORM SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. New storm sewers and appurtenances, modifications to existing storm sewer system and installation of roadside ditch culverts.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for storm sewers, including elliptical or box storm sewer, installed by open-cut, augered with or without casing, or tunneling is on linear foot basis. Measurement for storm sewers and roadside ditch culverts will be taken along center line of pipe from center line to center line of manholes or from end to end of culverts. Measurement for storm sewer will be taken along center line of storm sewer from inside wall of storm sewer junction box when installed in conjunction with storm sewer junction box. Payment will be made for each linear foot installed complete in place, including connections to existing manholes and inlets.

2. Payment for storm sewer leads, including elliptical leads, is on a linear foot basis.

3. Payment for corrugated metal pipe storm sewer outfall, including timber bents, is on a linear foot basis.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 DEFINITIONS

A. Long Run Culvert: A culvert which is 40 feet or more in length.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's literature for product specifications and installation instructions.

C. Submit proposed methods, equipment, materials, and sequence of operations for sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

D. For flexible pipe products, submit detailed calculations per AASHTO LRFD Bridge Design Specifications. Designs are required for each pipe location and are to be signed and sealed by a licensed engineer.

1.05 QUALITY ASSURANCE

A. The Condition for acceptance shall be watertight storm sewer that is watertight both in pipe-to-pipe joints and in pipe-to-manhole connections.

B. Provide manufacturer's certification to Specifications.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's recommendations.

B. Handle pipe, fittings, and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks or trailers. Do not use Materials cracked, gouged, chipped, dented, or otherwise damaged shall not be use materials for installation.

C. Store pipe and fittings on heavy timbers or platforms to avoid contact with ground.

D. Unload pipe, fittings, and appurtenances as close as practical to location of installation to avoid unnecessary handling.

E. Keep interiors of pipe and fittings free of dirt and foreign matter.

F. Store Thermoplastic (PVC, HDPE, PP) pipe out of direct sunlight.

PART 2 PRODUCTS

2.01 PIPE

A. Provide piping materials for storm sewers shall be of sizes and types specified unless otherwise indicated on Drawings.

B. In diameters where material alternatives are available, provide pipe from single manufacturer for each pipe diameter, unless otherwise approved by Project Manager or otherwise shown on Drawings.

C. Existing pipe that has been removed during construction cannot be reused.

2.02 PIPE MATERIAL SCHEDULE

A. Storm Sewer Pipe: Use pipe materials that conform to requirements specified in one or more of the following Sections as shown on the Drawings.

1. Section 02506 - Polyvinyl Chloride Pipe. Not allowed in the following applications:

a. Potentially Petroleum Contaminated Areas (PPCA).

b. Augering/ jacking.

2. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe and Section 02510 – Polypropylene (PP) Corrugated Wall Pipe. For use only where Storm Sewers are associated with Local Streets, where Local Street is defined by City of Houston Code of Ordinances 42-122.

3. Section 02611 - Reinforced Concrete Pipe.

4. Section 02612 - Precast Reinforced Concrete Box Sewers.

5. Section 02642 - Corrugated Metal Pipe use only where Corrugated Metal Pipe is shown on Drawings.

B. Driveway Culvert Pipe for Streets with Open Ditches: Use pipe materials conforming to requirements specified in one or more of the following Sections as shown on the Drawings.

1. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe and Section 02510 – Polypropylene (PP) Corrugated Wall Pipe. Use for Residential Culverts only. Use Concrete Pipe for long run culverts.

2. Section 02611 - Reinforced Concrete Pipe.

3. Section 02612 - Precast Reinforced Concrete Box Sewers.

C. Provide pipe meeting minimum class, dimension ratio, or other criteria indicated.

D. Pipe materials other than those listed above shall not be used for storm sewers.

2.03 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

A. Bedding and Backfill Material: Conform to requirements of Sections 02317 - Excavation and Backfill for Utilities, Section 02320 - Utility Backfill Materials, and Section 2321 - Cement Stabilized Sand, and Section 02322 - Flowable Fill.

B. Topsoil: Conform to requirements of Section 02911 - Topsoil.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic. Conform to requirements of Section 01555 - Traffic Control and Regulation.

B. Provide barricades, flashing warning lights, and signs for excavations. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections while Work is in progress or where traffic is affected by Work.

C. Immediately notify agency or company owning utility lines which are damaged, broken, or disturbed. Obtain approval from Project Manager and agency for repairs or relocations, either temporary or permanent.

D. Remove old pavements and structures, including sidewalks and driveways in accordance with requirements of Section 02221 - Removing Existing Pavements and Structures.

E. Install and operate dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

3.02 EXCAVATION

A. Earthwork. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings.

B. Line and Grade. Establish required uniform line and grade trench from benchmarks identified by Project Manager. Maintain this control for minimum of 100 feet behind and ahead of pipe-laying operation. Use laser beam equipment to establish and maintain proper line and grade of Work. Or use appropriately sized grade boards which are substantially supported.

C. Trench Excavation. Excavate pipe trenches to level as indicated on Standard Details. Backfill excavation with specified bedding material to level of lower one-third of pipe barrel. Tamp and compact backfill to provide bedding at indicated grade. Form bedding foundation to minimum depth of one-eighth of pipe diameter, but not less than 12-inches.

3.03 PIPE INSTALLATION

A. Install in accordance with pipe manufacturer's recommendations and as specified in this section.

B. Install pipe only after excavation is completed, bottom of trench is shaped, bedding material is installed, and trench has been approved by Project Manager.

C. Install pipe to line and grade indicated on Drawings. Place pipe so that it has continuous bearing of barrel on bedding material with no voids, and is laid in trench so interior surfaces of pipe follows grades and alignments indicated.

D. Install pipe with bells of pipe facing upstream of anticipated flow.

E. Form concentric joint with each section of adjoining pipe to prevent offsets.

F. Place and drive home newly laid sections with a sling or come-a-long winches to eliminate damage to sections. Unless otherwise approved by Project Manager, provide end protection

to prevent damage while using back hoes or similar powered equipment to drive home newly laid sections.

G. Keep interior of pipe clean as installation progresses.

H Keep excavations free of water during construction and until final inspection.

I. When work is not in progress, cover exposed ends of pipes with pipe plug specifically designed to prevent foreign material from entering pipe.

J. For Flexible Pipe Products:

1. Provide a minimum cover as per City Standard detail from top of pavement to top of pipe, but no less than 2 feet.

2. Accomplish transitions to different material of pipe in a manhole or inlet box. No adapter, coupling for dissimilar pipe, or saddle connections allowed.

3. Provide pipe sections in standard lengths with minimum length of 13 feet. Pipe may be field modified to shorten length no less than 4 feet, unless otherwise approved by Project Manager. Field modify pipe per manufacturer's recommendations.

4. No beveling at joint allowed. Cut to be perpendicular to longitudinal axis.

5. Provide gasketed bell and spigot joints installed per manufacturer's recommendations. Gasketed pipe joints; clean and free of debris, show no leakage after installation.

3.04 PIPE INSTALLATION OTHER THAN OPEN CUT OR TUNNELING

A. Conform to requirements of Section 02448 - Pipe and Casing Augering for Sewers where required.

B. Conform to requirements of Section 02441 - Microtunneling where required.

C. Conform to requirements of Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels where required.

D. Not allowed for plastic sewer pipe.

3.05 INSTALLATION OF APPURTENANCES

A. Construct manholes to conform to requirements of Sections 02081 - Cast-in-place Concrete Manholes and Section 02082 - Precast Concrete Manholes. Install frames, grate rings, and covers to conform to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

B. Install PVC pipe culverts with approved end treatments. Approved end treatments include concrete headwalls, wingwalls and collars.

C. Install HDPE and PP pipe culverts with approved end treatments. Approved end treatments include concrete headwalls, wingwalls and collars.

D. Install inlets, headwalls, and wingwalls to conform to requirements of Section 02632 - Cast-in-place Inlets, Headwalls, and Wingwalls and Section 02633 - Precast Concrete Inlets, Headwalls, and Wingwalls.

E. Rehabilitate existing manholes to conform to requirements of Section 02555 – Manhole Rehabilitation. Adjust manhole covers and inlets to grade conforming to requirements of Section 02086 - Adjusting Manholes, Inlets, and Valve Boxes to Grade.

F. Dimension for Type C and Type E manholes shall be as shown on Drawings.

3.06 INSPECTION AND TESTING

A. Perform post installation television inspection in accordance with Section 02531 – Gravity Sanitary Sewers. Hand held cameras may be used in storm sewers in lieu of requirements of Paragraph 3.09 of Section 02531 – Gravity Sanitary Sewers. Clearly stencil distance markings on each joint of pipe to indicate distance from starting manhole when using hand held cameras.

B. MANDREL TESTING: use a mandrel to test flexible pipe for deflection. Refer to Section 02533 – Acceptance Testing for Sanitary Sewers for the mandrel and test requirements.

3.07 BACKFILL AND SITE CLEANUP

A. Backfill trench after pipe installation is inspected and approved by Project Manager.

B. Backfill and compact soil in accordance with Section 02317 - Excavation and Backfill for Utilities.

C. Repair and replace removed or damaged pavement and sidewalks as specified in Section 02951 - Pavement Repair and Restoration.

D. In unpaved areas, grade surface as uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil and seed according to requirements of Section 02921 Hydro Mulch Seeding, or Section 02922 - Sodding, as required.

END OF SECTION

SECTION 02633

PRECAST CONCRETE INLETS, HEADWALLS, AND WINGWALLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Precast concrete inlets for storm or sanitary sewers, including cast iron frame and plate or grate.

B. Precast concrete headwalls and wingwalls for storm sewers.

C. Precast junction box with lid or grate top.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for inlets is on unit price basis for each inlet installed.

2. Payment for headwalls and wingwalls is on unit price basis for each headwall and wingwall installed.

3. Payment for junction box with lid or grate top is on unit price basis for each junction box installed.

4. Payment for inlets, headwalls, wingwalls, and junction boxes includes connection of lines and furnishing and installing frames, grates, rings, and covers.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.

B. ASTM C 858 - Standard Specification for Underground Precast Concrete Utility Structures.

C. ASTM C 891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings for approval of design and construction details for precast concrete inlets, junction box headwalls, and wingwalls. Precast units differing from standard designs shown on Drawings will be rejected unless shop drawing submittals are approved. Clearly show proposed substitution is equal or superior in every aspect to standard designs.

C. Submit manufacturers' data and details for frames, grates, rings, and covers.

1.05 STORAGE AND SHIPMENT

A. Store precast units on level blocking. Do not place loads until design strength is reached. Shipment of acceptable units may be made when 28-day strength requirements have been met.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Provide concrete for precast machine-made units meeting requirements of ASTM C 858 regarding reinforced concrete, cement, aggregate, mixture, and concrete test. Minimum 28-day compressive strength shall be 4,000 psi.

B. Reinforcing Steel: Place reinforcing steel to conform to details shown on Drawings and as follows:

1. Provide positive means for holding steel cages in place throughout production of concrete units. Maximum variation in reinforcement position is plus or minus 10 percent of wall thickness or plus or minus 1/2-inch, whichever is less. Regardless of variation, maintain minimum cover of concrete over reinforcement as shown on Drawings.

2. Welding of reinforcing steel is not permitted unless noted on Drawings.

C. Mortar and Hydraulic Cement: Conform to requirements of Section 04061 - Mortar.

D. Miscellaneous Metal: Cast-iron frames and plates conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

2.02 SOURCE QUALITY CONTROL

A. Tolerances: Allowable casting tolerances for concrete units are plus or minus 1/4 inch from dimensions shown on Drawings. Concrete thickness in excess of that required will not

constitute cause for rejection provided that excess thickness does not interfere with proper jointing operations.

B. Precast Unit Identification: Mark date of manufacture and name or trademark of manufacturer clearly on inside of inlet, headwall, or wingwall.

C. Rejection: Precast units rejected for non-conformity with these specifications and for following reasons:

1. Fractures or cracks passing through shell, except for single end crack that does not exceed depth of joint.

2. Surface defects indicating honeycombed or open texture.

3. Damaged or misshaped ends, where damage would prevent making satisfactory joint.

D. Replacement: Immediately remove rejected units from Work site and replace with acceptable units.

E. Repairs: Occasional imperfections resulting from manufacture or accidental damage may be repaired if, in opinion of Project Manager, repaired units conform to requirements of these specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct.

B. Verify compacted subgrade will support loads imposed by inlets.

3.02 INSTALLATION

A. Install units complete in place to dimensions, lines, and grades as shown on Drawings.

B. Excavate in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities.

C. Bed precast concrete units on foundations of firm, stable material shaped to conform to shape of unit bases.

D. Provide adequate means to lift and place concrete units.

3.03 FINISHES

B. Use hydraulic cement to seal joints, fill lifting holes and as otherwise required.

B. When box section of inlet has been completed, shape floor of inlet with mortar to conform to Drawing details.

C. Adjust cast iron inlet plate frames to line, grade, and slope shown on Drawings. Grout frame in place with mortar.

3.04 QUALITY CONTROL

A. Verify that inlets are free of leaks. Repair leaks in approved manner.

3.05 CONNECTIONS

A. Connect storm sewer leads to inlets as shown on Drawings. Seal connections inside and outside with hydraulic cement. Make connections watertight.

3.06 BACKFILL

A. Backfill area of excavation surrounding each completed inlet, headwall, or wingwall according to requirements of Section 02317 - Excavation and Backfill for Utilities.

END OF SECTION

SECTION 02711

HOT MIX ASPHALT BASE COURSE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of compacted mixture of coarse and fine aggregates, and asphalt binder.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for hot mix asphalt base is on a per ton basis.

2 Payment for hot mix asphalt base for transitions and base repairs is on a per ton basis.

3. No separate payment will be made for hot mix asphaltic base for temporary driveway, temporary detour pavement, temporary roadway shoulders, etc. Include payment in unit price for respective driveway (Section 02714 – Flexible Base Course for Temporary Driveways) or temporary pavement (Section 02741 – Asphaltic Concrete Pavement) section.

4. Measurement:

a. Match actual pavement area placed or replaced but no greater than maximum pavement replacement limits and thickness designated or shown on Drawings.

b. Include installed hot mix asphalt base course material that extends one foot beyond outside edge of pavement to be replaced, except where proposed pavement section shares common edge with existing pavement section.

c. Actual quantity for payment purpose as measured and calculated in this section shall not exceed the maximum volume-weight conversion rate of 105 pounds per square yard area per inch thickness.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. AASHTO T201 - Standard Specification for Kinematic Viscosity of Asphalts (Bitumens).

B. AASHTO T202 - Standard Specification for Viscosity of Asphalt by Vacuum Capillary Viscometer.

C. ASTM C 33 - Standard Specifications for Concrete Aggregate.

D. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

E. ASTM C 136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

F. ASTM D 4402 - Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using Rotational Viscometer.

G. TxDOT Tex-106-E - Calculating the Plasticity Index of Soils.

H. TxDOT Tex-126-E - Molding, Testing, and Evaluating Bituminous Black Base Material.

I. TxDOT Tex-200-F- Sieve Analysis of Fine and Coarse Aggregates.

J. TxDOT Tex-203-F - Sand Equivalent Test.

K. TxDOT Tex-204-F - Design of Bituminous Mixtures.

L. TxDOT Tex-207-F - Determining Density of Compacted Bituminous Mixtures.

M. TxDOT Tex-208-F - Test for Stabilometer Value of Bituminous Mixtures.

N. TxDOT Tex-227-F - Theoretical Maximum Specific Gravity of Bituminous Mixtures.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certificates that asphalt materials and aggregates meet requirements of Paragraph 2.01, Materials.

C. Submit proposed mix and test data for each type of base course in Work.

D. Submit manufacturer's description and characteristics of mixing plant for approval.

E. Submit manufacturer's description and characteristics of spreading and finishing machine for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coarse Aggregate:

1. Use crushed gravel or crushed stone, or combination retained on No. 10 sieve, uniform in quality throughout and free from dirt, organic, or other injurious material occurring either free or as coating on aggregate. Conform aggregate o ASTM C 33 except for gradation. Furnish rock or gravel with Los Angeles abrasion loss not to exceed 40 percent by weight when tested in accordance with ASTM C 131.

2. Reclaimed asphalt pavement (RAP) or reclaimed Portland cement concrete pavement (RPCCP) are permitted as aggregates for hot mix asphalt base course if combined aggregate criteria, gradation, and mixture properties are met.

B. Fine Aggregate: Sand or stone screenings, or combination thereof, passing No. 10 sieve. Conform aggregate to ASTM C 33 except for gradation. Use sand composed of sound, durable stone particles free from loams or other deleterious foreign matter. Furnish screenings of same or similar material as specified for coarse aggregate. Plasticity index of that part of fine aggregate passing No. 40 sieve shall be not more than 6 when tested by TxDOT Tex-106-E. Sand equivalent shall have minimum value of 45 when tested by TxDOT Tex-203-F.

C. Composite Aggregate: Conform to following limits when graded in accordance with ASTM C 136. Provide either coarse or fine aggregate where designated on the Drawings.

GRADATION OF COMPOSITE AGGREGATE **Percent Passing by Weight or Volume**		
Sieve Size	Type **A Coarse**	Type **B Fine Base**
1 1/2"	98.0-100.0	-
1 1/4"	-	-
1"	78.0-94.0	98.0-100.0
3/4"	64.0-85.0	84.0-98.0
1/2"	50.0-70.0	-
3/8"	-	60.0 to 80.0
#4	30.0-50.0	40.0 to 60.0
#8	22.0-36.0	29.0-43.0
#30	8.0-23.0	13.0-28.0
# 50	3.0-19.0	6.0-20.0
#200	2.0-7.0	2.0-7.0
VMA % Minimum	12.0	13.0
*2 to 8 when Test Method Tex-200-F, Part II (Washed Sieve Analysis) is used.		

D. Asphalt Binder: Moisture-free homogeneous material meeting following requirements:

SPECIFICATION	PG 64 – 22
Average 7-day Maximum Pavement Design Temperature, degrees C[a]	<64
Minimum Pavement Design Temperature, degrees C[a]	>-22
Original Binder	
Flash Point Temperature, T48, Minimum degrees C	230
Viscosity, ASTM D 4402, [b] Maximum 3 Pa.s (3000cP), Test Temperature, degrees C	135
Dynamic Shear, TP5; [c]G*/sine[], Minimum, 1.00kPaTest Temperature @ 10rad/sec, degrees C	64
Rolling Thin Film Oven (T240) or Thin Film Oven (T179) Residue	
Mass Loss, Maximum, %	- 1.00
Dynamic Shear, TP5; G*/sine[], Minimum, 2.20 kPa Test Temperature @ 10rad/sec, degrees C	64
Pressure Aging Vessel Residue (PPI)	
PAV Aging Temperature, degrees C [d]	100
Dynamic Shear, TP5; G*/sine[], Maximum, 5000 kPa Test Temperature @ 10rad/sec, degrees C	25
Physical Hardening [e]	Report
Creep Stiffness, TP1; [f] S, Maximum, 300 Mpa; m-value, Minimum, 0.300 Test Temperature @ 60 sec, degrees C	-12
Direct Tension, TP3; [f] Failure Strain, Minimum, 1.0%; Test Temperature @ 1.0 mm/min, degrees C	-12

Notes:

[a] Pavement temperature can be estimated from air temperatures using algorithm contained in TxDOT testing procedures.

[b] The requirement may be waived at discretion of Project Manager if supplier warrants that asphalt binder can be adequately pumped and mixed at temperatures that meet applicable safety standards.

[c] For quality control of unmodified asphalt cement production, measurement of viscosity of original asphalt cement may be substituted for dynamic shear measurements of G*/sine [ ] at test temperature where asphalt is Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary of rotational viscometry (AASHTO T 201 or T202).

[d] The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures: 90 C, 100 C, or 110 C. The PAV aging temperature is 100 C for PG64 and PG70.

[e] Physical Hardening - TP 1 is performed on a set of asphalt beams according to Section 13.1, except conditioning time is extended to 24 hours plus of minus 10 minutes at 10 C above minimum performance temperature. The 24-hour stiffness and m-value are reported for information purposes only.

[f] If creep stiffness is below 300 MPa, the direct tension test is not required. If creep stiffness is between 300 and 600 MPa the direct tension failure strain requirement can be used in lieu of creep stiffness requirement. The m-value requirement must be satisfied in both cases.

E. Reclaimed asphalt pavement (RAP) may be used at a rate no greater than 20 percent.

2.02 EQUIPMENT

A. Mixing Plant: Weight-batching or drum mix plant with capacity for producing continuous mixtures meeting specifications. With exception of a drum mix plant, the plant shall have satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins, and dust collectors.

B. Provide equipment to supply materials adequately in accordance with rated capacity of plant and produce finished material within specified tolerances. Following equipment is essential:

1. Cold aggregate bins and proportioning device

2. Dryer

3. Screens

4. Aggregate weight box and batching scales

5. Mixer

6. Asphalt storage and heating devices

7. Asphalt measuring devices

8. Truck scales

C. Bins: Separate aggregate into minimum of four bins to produce consistently uniform grading and asphalt content in completed mix. One cold feet bin per stockpile is required.

2.03 MIXES

A. Employ certified testing laboratory to prepare design mixes.

1. Test in accordance with TxDOT Tex-126-E, TxDOT Tex-204-F, TxDOT Tex-208-F, and TxDOT Tex-227-F.

2. Verify mixture design properties for plant-produced mixture. Demonstrate that asphalt plant is capable of producing mixture meeting design volumetric and stability requirements before placement begins.

B. Density, Stability, and Air Voids Requirements. Select asphalt binder content for base courses to result in 3 to 5 percent air voids in laboratory molded specimens, while meeting minimum VMA requirement for selected mixture classification.

Percent Density		Percent	HVEEM Stability Percent	Percent Asphalt Content	
Min	Max.	Optimum	Not Less Than	Min.	Max.
94.5	97.5	96	35	3.5	7

PART 3 EXECUTION

3.01 PREPARATION

A. Complete backfill of new utilities below future grade.

B. Verify lines and grades are correct.

C. Prepare subgrade in accordance with requirements of Section 02330 - Embankment and Section 02315 - Roadway Excavation or Section 02336 - Lime Stabilized Subgrade and Section 02337 - Lime/Fly-Ash Stabilized Subgrade, and Section 02338 - Portland Cement Stabilized Subgrade. Subgrade preparation may also refer to Section 02321 - Cement Stabilized Sand or Section 02713 - Recycled Crushed Concrete Base Course.

D. Correct subgrade deviations in excess of plus or minus 1/4 inch in cross section, or in 16 foot length by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

3.02 PLACEMENT

A. Place base when surface temperature taken in shade and away from artificial heat is above 40 degrees F and rising. Do not place asphalt base when temperature of surface to receive base course is below 50 degrees F and falling.

B. Haul prepared and heated asphalt base mixture to project in tight vehicles previously cleaned of foreign material. Mixture shall be at temperature between 250 degrees F and 325 degrees F when laid.

C. Place hot mix asphalt base course in compacted lifts no greater than 4 inches thick, unless permitted in writing by Engineer.

D. Place courses as nearly continuously as possible. Place material with approved mechanical spreading and finishing machine of screeding or tamping type. Spread lifts to attain smooth course of uniform density to section, line, and grades as indicated on Drawings.

E. In areas with limited space where use of paver or front-end loader is impractical, spread by hand and compact asphalt by mechanical means. Carefully place materials to avoid segregation of mix; do not broadcast material. Remove lumps that do not break down readily.

3.03 JOINTS

A. Transverse Joints. Pass roller over unprotected ends of freshly laid mixture only when mixture has cooled. When work is resumed, cut back placed material to produce slightly beveled edge for full thickness of course. Remove old material which has been cut away and lay new mix against fresh cut.

B. Existing pavement. When new asphalt is laid against existing asphalt pavement, saw cut existing asphalt to full depth creating vertical face. Clean joint and apply tack coat before placement.

3.04 COMPACTION

A. Construct test strip to identify correct type, number, and sequence of rollers necessary to obtain specified in-place density or air-voids. Prepare test strip at least 500 feet in length, comparable to placement and compaction conditions for Project.

B. Begin rolling while pavement is still hot and as soon as it will bear roller without undue displacement or hair line cracking. Keep wheels properly moistened with water to prevent adhesion of surface mixture. Do not use excessive water; do not use petroleum by-products.

C. Compact surface thoroughly and uniformly with power-driven equipment capable of obtaining required compaction. Obtain subsequent compression by starting at side and rolling longitudinally toward center of pavement, overlapping on successive trips by at least one-half width of rear wheels. Make alternate trips slightly different in length. Continue rolling until no further compression can be obtained and rolling marks are eliminated. Complete rolling before mat temperature drops below 175 degrees F.

D. Along walls, curbs, headers, similar structures, and in locations not accessible to rollers, compact mixture thoroughly with lightly oiled tamps.

E. Compact base course to a minimum density of 91 percent (TxDOT Tex-227-F).

3.05 TOLERANCES

A. Pavement Repairs.

1. Furnish templates for checking surface of finished sections. Maximum deflection of templates, when supported at center, shall not exceed 1/4 inch.

2. Completed surface, when tested with 10 foot straight edge laid parallel to center line of pavement, shall show no deviation in excess of 1/4 inch in 10 feet. Correct surface not meeting this requirement.

3.06 FIELD QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.For in-place depth and density, take minimum of one core at random locations for each 1000 feet of single lane pavement. On a 2-lane pavement, take samples at random every 500 feet from alternating lanes. Take cores for parking lots every 500 square yards of base to determine in-place depth and density. If cul-de sac or streets are less than 500 feet, minimum of 2 cores (one per lane) will be procured. On small projects, take a minimum of two cores for each day's placement. For first days placement and prior to coring, minimum of 5 nuclear gauge readings will be performed at each core location to establish correlation between nuclear gauge (wet density reading) and core (bulk density). This process will continue for each day's placement until engineer determines that a good bias has been established for that nuclear gauge.

B. Determine in-place density in accordance with TxDOT Tex-207-F and Tex-227-F from cores or sections of asphaltic base located near each core. Other methods of determining in-place density, which correlate satisfactorily with results obtained from roadway specimens, may be used when approved by Project Manager.

C. Request, at option, three additional cores within a 5-foot radius of core indicating nonconforming in-place depth at no additional cost to City. In-place depth at these locations shall be average depth of four cores.

D. Fill cores and density test sections with new compacted asphalt base or cold patch material.

3.07 NONCONFORMING PAVEMENT

A. Re-compact and retest nonconforming street sections not meeting surface test requirements. Patch asphalt pavement sections in accordance with procedures established by Asphalt Institute. Retesting is at no cost to the City.

B. Remove and replace areas of asphalt base found deficient in thickness by more than 10 percent. Remove and replace areas of asphalt base found deficient in density. Use new asphalt base of thickness shown on Drawings.

C. Replace or correct nonconforming pavement sections at no additional cost to City.

3.08 PROTECTION

A. Do not open base to traffic until 12 hours after completion of rolling, or as shown on Drawings.

B. Maintain asphalt base in good condition until completion of Work.

C. Repair defects immediately by replacing base to full depth.

END OF SECTION

SECTION 02751

CONCRETE PAVING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete paving.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete paving is on square yard basis. Separate pay items are used for each different required thickness of pavement.

2. Payment for concrete paving, high early strength, is on square yard basis.

3. Payment for pavement repair or pavement replacement for utility projects is on a square yard basis and includes base materials in accordance with Section 02951 – Pavement Repair and Restoration.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

5. Refer to Paragraph 3.15, Unit Price Adjustment.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

B. ASTM A615 - Standard Specification for Deformed and Carbon-Steel Bars for Concrete Reinforcement.

C. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

D. ASTM C 33 - Standard Specifications for Concrete Aggregates.

E. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

F. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

G. ASTM C 42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

H. ASTM C 78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third Point Loading).

I. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

J. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

K. ASTM C 136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

L. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

M. ASTM C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.

N. ASTM C 150 - Standard Specification for Portland Cement.

O. ASTM C 174 - Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores.

P. ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

Q. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.

R. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

S. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for use in Concrete.

T. TxDOT Tex-203-F - Sand Equivalent Test.

U. TxDOT Tex-406-A - Material Finer than 75 <λm (No. 200) Sieve In Mineral Aggregates (Decantation Test for Cement Aggregates).

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed mix design and test data for each type and strength of concrete in Work. Include proportions and actual flexural strength obtained from design mixes at required test ages.

C. Submit for approval manufacturer's description and characteristics for mixing equipment, and for traveling form paver, when proposed for use.

D. Submit manufacturer's certificates giving properties of reinforcing steel. Include certificate of compliance with ASTM A 1064. Provide specimens for testing when required by Project Manager.

1.05 HANDLING AND STORAGE

A. Do not mix different classes of aggregate without written permission of Project Manager.

B. Class of aggregate being used may be changed before or during Work with written permission of Project Manager. Comply new class with specifications.

C. Reject segregated aggregate. Before using aggregate whose particles are separated by size, mix them uniformly to grading requirements.

D. Reject aggregates mixed with dirt, weeds, or foreign matter.

E. Do not dump or store aggregate in roadbed.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland Cement:

1. Sample and test cement to verify compliance with Standards of ASTM C 150, Type I or Type III.

2. Bulk cement which meets referenced standards may be used when method of handling is approved by Project Manager. When using bulk cement, provide satisfactory weighing devices.

3. Fly ash which meets standards of ASTM C 618 may be used as mineral fill when method of handling is approved by Project Manager.

B. Water: Conform to requirements for water in ASTM C 94.

C. Coarse Aggregate: Crushed stone, gravel, or combination thereof, which is clean, hard, and durable, conforms to requirements of ASTM C 33, and has abrasion loss not more than 45 percent by weight when subjected to Los Angeles Abrasion Test (ASTM C 131).

1. Maximum percentage by weight of deleterious substances shall not exceed following values:

Item	Percent by Weight of Total Sample Maximum
Clay lumps and friable particles	3.0
Material finer than 75-µm (No. 200) sieve:	
Concrete subject to abrasion	3.0*
All Other concrete	5.0*
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

* In case of manufactured sand, when material finer than 75-µm (No. 200) sieve consists of dust of fracture, essentially free from clay or shale, these limits may be increased to 5 and 7 percent, respectively.

2. Conform coarse aggregate (size 1 1/2-inch to No. 4 sieve) to requirements of ASTM C33. Use gradation within following limits when graded in accordance with ASTM C 136:

Sieve Designation (Square Openings)	Percentage by Weight
Retained on 1 3/4" sieve	0
Retained on 1 1/2"sieve	0 to 5
Retained on 3/4" sieve	30 to 65
Retained on 3/8" sieve	70 to 90
Retained on No. 4 sieve	95 to 100
Loss by Decantation Test *Method Tex-406-A	1.0 maximum

* In case of aggregates made primarily from crushing of stone, when material finer than 200 sieve is dust of fracture essentially free from clay or shale as established by Part III of TxDOT Tex-406-A, percent may be increased to 1.5.

D. Fine Aggregate: Sand, manufactured sand, or combination thereof, composed of clean, hard, durable, uncoated grains, free from loams or other injurious foreign matter. Conform fine aggregate for concrete to requirements of ASTM C 33. Use gradation within following limits when graded in accordance with ASTM C 136:

Sieve Designation (Square Openings)	Percentage by Weight
Retained on 3/8" sieve	0
Retained on No. 4 sieve	0 to 5
Retained on No. 8 sieve	0 to 20
Retained on No. 16 sieve	15 to 50
Retained on No. 30 sieve	35 to 75
Retained on No. 50 sieve	65 to 90
Retained on No. 100 sieve	90 to 100
Retained on No. 200 sieve	97 to 100

1. When subjected to color test for organic impurities (ASTM C 40), fine aggregate shall not show color darker than standard color. Fine aggregate shall be subjected to Sand Equivalent Test (Tex-203-F). Sand equivalent value shall not be less than 80, unless higher value is shown on Drawings.

E. Mineral Filler: Type “C” or Type “F” fly ash of acceptable quality and meeting requirements of ASTM C 618 may be used as mineral admixture in concrete mixture. When fly ash mineral filler is used, store and inspect in accordance with ASTM C 618. Do not use fly ash in amounts to exceed 25 percent by weight of cementatious material in mix design. Cement content may be reduced when strength requirements can be met. Note: When fly ash is used, term "cement" is defined as cement plus fly ash.

F. Air Entraining Agent: Furnish air entraining agent conforming to requirements of ASTM C 260.

G. Water Reducer: Water reducing admixture conforming to requirements of ASTM C 494 may be used when required to improve workability of concrete. Amount and type of admixture is subject to approval by Project Manager.

H. Reinforcing Steel:

1. Provide new billet steel manufactured by open hearth process and conforming to ASTM A 615, Grade 60. Store steel to protect it from mechanical injury and rust. At time of placement, steel shall be free from dirt, scale, rust, paint, oil, or other injurious materials.

2. Cold bend reinforcing steel to shapes shown. Once steel has been bent, it may not be rebent.

3. Provide wire fabric conforming to ASTM A 1064. Use fabric in which longitudinal and transverse wires have been electrically welded at points of intersection. Welds shall have sufficient strength not to be broken during handling or placing. Conform welding and fabrication of fabric sheets to ASTM A 1064.

2.02 EQUIPMENT

A. Conform Equipment to requirements of ASTM C94.

2.03 MIXING

A. Flexural strength shall be as specified using test specimens prepared in accordance with ASTM C 31 and tested in accordance with ASTM C78 (using simple beam with third-point loading). Compressive strength shall be as specified using test specimens prepared in accordance with ASTM C 31 and tested in accordance with ASTM C 39. Determine and measure batch quantity of each ingredient, including water for batch designs and all concrete produced for Work. Mix shall conform to these specifications and other requirements indicated on Drawings.

B. Mix design to produce concrete which will have flexural strength of 500 psi at 7 days and 600 psi at 28 days. Minimum compressive strength shall be 3,000 pounds per square inches for 7 days and 4,000 pounds per square inches at 28 days when tested in accordance with ASTM C39. Slump of concrete shall be at least 2-inches but no more than 5-inches, when tested in accordance with ASTM C143.

1. Concrete pavement, including curb, curb and gutter, and saw-tooth curb, shall contain at least 5 1/2 sacks (94 pounds per sack) of cement per cubic yard, with not more than 6.5 gallons of water, net, per sack of cement (water-cement ratio maximum 0.57). Determine cement content in accordance with ASTM C 138. Addition of mineral filler may be used to improve workability or plasticity of concrete to limits specified.

2. Coarse dry aggregate shall not exceed 85 percent of loose volume of concrete.

3. Add air-entraining admixture to ensure uniform distribution of agent throughout batch. Base air content of freshly mixed air-entrained concrete upon trial mixes with materials to be used in Work, adjusted to produce concrete of required plasticity and workability. Percentage of air entrainment in mix shall be 4 1/2 percent plus or minus 1 1/2 percent. Determine air content by testing in accordance with ASTM C 231.

4. Use retardant when temperature exceeds 90 degrees F. Proportion as recommended by manufacturer. Use same brand as used for air-entraining agent. Add and batch material using same methods as used for air-entraining agent.

C. Use high early strength concrete pavement to limits shown on Drawings. Design to meet following:

1. Concrete Mix: Flexural strength greater than or equal to 500 psi at 72 hours.

2. Cement: Minimum of 7 sacks of cement per cubic yard of concrete.

3. Water-Cement Ratio maximum of 0.45. Slump of concrete shall a maximum of 5-inches, when tested in accordance with ASTM C 143.

4. Other requirements for proportioning, mixing, execution, testing, etc., shall be in accordance with this Section 02751 - Concrete Paving.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted base is ready to support imposed loads and meets compaction requirements.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Properly prepare, shape and compact each section of subgrade before placing forms, reinforcing steel or concrete. After forms have been set to proper grade and alignment, use subgrade planer to shape subgrade to its final cross section. Check contour of subgrade with template.

B. Remove subgrade that will not support loaded form. Replace and compact subgrade to required density.

3.03 EQUIPMENT

A. Alternate equipment and methods, other than those required by this Section, may be used provided equal or better results will be obtained. Maintain equipment for preparing subgrade and for finishing and compacting concrete in good working order.

B. Subgrade Planer and Template:

1. Use subgrade planer with adjustable cutting blades to trim subgrade to exact section shown on Drawings. Select planer mounted on visible rollers which ride on forms. Planer frame must have sufficient weight so that it will remain on form, and have strength and rigidity that, under tests made by changing support from wheels to center, planer will not develop deflection of more than 1/8-inch. Tractors used to pull planer shall not produce ruts or indentations in subgrade. When slip form method of paving is used, operate subgrade planer on prepared track grade or have it controlled by electronic sensor system operated from string line to establish horizontal alignment and elevation of subbase.

2. Provide template for checking contour of subgrade. Template shall be long enough to rest upon side forms and have strength and rigidity that, when supported at center, maximum deflection shall not exceed 1/8-inch. Fit template with accurately adjustable rods projecting downward at 1-foot intervals. Adjust these rods to gauge

cross sections of slab bottom when template is resting on side forms.

C. Machine Finisher: Provide power-driven, transverse finishing machine designed and operated to strike off and consolidate concrete. Machine shall have two screeds accurately adjusted to crown of pavement and with frame equipped to ride on forms. Use finishing machine with rubber tires when it operates on concrete pavement.

D. Hand Finishing:

1. Provide mechanical strike and tamping template 2-feet longer than width of pavement to be finished. Shape template to pavement section.

2. Provide two bridges to ride on forms and span pavement for finishing expansion and dummy joints. Provide floats and necessary edging and finishing tools.

E. Burlap Drag or transverse broom for Finishing Slab: Furnish four plies of 10-ounce burlap material fastened to bridge to form continuous strip of burlap full width of pavement. Maintain contact 3-foot width of burlap material with pavement surface. Keep burlap drags clean and free of encrusted mortar.

F. Vibrators: Furnish mechanically-operated, synchronized vibrators mounted on tamping bar which rides on forms and hand-manipulated mechanical vibrators. Furnish vibrators with frequency of vibration to provide maximum consolidation of concrete without segregation.

G. Traveling Form Paver: Approved traveling form paver may be used in lieu of construction methods employing forms, consolidating, finishing and floating equipment. Meet requirements of this specification for subgrade, pavement tolerances, pavement depth, alignments, consolidation, finishing and workmanship. When traveling form paver does not provide concrete paving that meets compaction, finish, and tolerance requirements of this Specification, immediately discontinue its use and use conventional methods.

1. Equip traveling paver with longitudinal transangular finishing float adjustable to crown and grade. Use float long enough to extend across pavement to side forms or edge of slab.

2. Ensure that continuous deposit of concrete can be made at paver to minimize starting and stopping. Use conventional means of paving locations inaccessible to traveling paver, or having horizontal or vertical curvature that traveling paver cannot negotiate.

3. Where Drawings require tie bars for adjacent paving, securely tie and support bars to prevent displacement. Tie bars may be installed with approved mechanical bar inserter mounted on traveling-form paver. Replace pavement in which tie bars assume final position other than that shown on Drawings.

3.04 FORMS

A. Side Forms: Use metal forms of approved shape and section. Preferred depth of form is equal to required edge thickness of pavement. Forms with depths greater or less than required edge thickness of pavement will be permitted, provided difference between form depth and edge thickness when not greater than 1-inch, and further provided that forms of depth less than pavement edge are brought to required edge thickness by securely attaching wood or metal strips to bottom of form, or by grouting under form. Bottom flange of form shall be same size as thickness of pavement. Aluminum forms are not allowed. Forms shall be approved by Project Manager. Length of form sections shall be not less than 10-feet and each section shall provide for staking in position with not less than 3 pins. Flexible or curved forms of wood or metal of proper radius shall be used for curves of 200-foot radius or less. Forms shall have ample strength and shall be provided with adequate devices for secure setting so that when in-place they will withstand, without visible springing or settlement, impact and vibration of finishing machine. In no case shall base width be less than 8-inches for form 8-inches or more in height. Forms shall be free from warp, bends or kinks and shall be sufficiently true to provide straight edge on concrete. Top of each form section, when tested with straight edge, shall conform to requirements specified for surface of completed pavement. Provide sufficient forms for satisfactory placement of concrete. For short radius curves, forms less than 10-feet in length or curved forms may be used. For curb returns at street intersections and driveways, wood forms of good grade and quality may be used.

B. Form Setting:

1. Rest forms directly on subgrade. Do not shim with pebbles or dirt. Accurately set forms to required grade and alignment and, during entire operation of placing, compacting and finishing of concrete, do not deviate from this grade and alignment more than 1/8-inch in 10-feet of length. Do not remove forms for at least 8 hours after completion of finishing operations. Provide supply of forms that will be adequate for orderly and continuous placing of concrete. Set forms and check grade for at least 300-feet ahead of mixer or as approved by Project Manager.

2. Adjacent slabs may be used instead of forms, provided that concrete is well protected from possible damage by finishing equipment. Do not use adjacent slabs for forms until concrete has aged at least 7 days.

3. Prior to form setting, grade subgrade appropriately so that when the forms are set, and the concrete is poured, finished, and cured, there is positive drainage, free of sitting water / ponding in the gutter ("gutter ponds") or on the pavement area of new panels. This requirement may not be capable of being met at the construction joint between an existing pavement panel and a new individual pavement panel that is properly installed to match the existing panel. However, this requirement shall be met between two new panels and within the area of new panels.

3.05 REINFORCING STEEL AND JOINT ASSEMBLIES

A. Place reinforcing steel and joint assemblies and position securely as indicated on Drawings. Wire reinforcing bars securely together at intersections and splices. Bars and coatings shall be free of rust, dirt or other foreign matter when concrete is placed. Secure reinforcing steel to chairs.

B. Position pavement joint assemblies at required locations and elevations, and rigidly secure in position. Install dowel bars in joint assemblies, each parallel to pavement surface and to center line of pavement, as shown.

C. Cut header boards, joint filler, and other material used for forming joints to receive each dowel bar.

D. Secure in required position to prevent displacement during placing and finishing of concrete.

E. Drill dowels into existing pavement, secure with epoxy, and provide paving headers as required to provide rigid pavement sections.

F. Use sufficient number of chairs for steel reinforcement bars to maintain position of bars within allowable tolerances. Place reinforcement as shown on Drawings. In plane of steel parallel to nearest surface of concrete, bars shall not vary from plan placement by more than 1/12 of spacing between bars. In plane of steel perpendicular to nearest surface of concrete, bars shall not vary from plan placement by more than 1/4-inch.

3.06 FIBROUS REINFORCING

A. Do not use fibrous reinforcing to replace structural, load-bearing, or moment-reinforcing steel.

3.07 PLACEMENT

A. Place concrete when air temperature taken in shade and away from artificial heat is above 35 degrees F and rising. Do not place concrete when temperature is below 40 degrees F and falling.

B. Place concrete within 90 minutes after initial water had been added. Remove and dispose of concrete not placed within this period.

C. Concrete slump during placement shall be 1 to 5-inches, except when using traveling-form paver, slump shall be maximum of 2-inches.

D. Deposit concrete continuously in successive batches. Distribute concrete in manner that will require as little rehandling as possible. Where hand spreading is necessary, distribute concrete with shovels or by other approved methods. Use only concrete rakes in handling concrete. At placement interruption of more than 30 minutes, place transverse construction joint at stopping point. Remove and replace sections less than 10-feet long.

E. Take special care in placing and spading concrete against forms and at longitudinal and transverse joints to prevent honeycombing. Voids in edge of finished pavement will be cause for rejection.

3.08 COMPACTION

A. Consolidate concrete using mechanical vibrators as specified herein. Extend vibratory unit across pavement, not quite touching side forms. Space individual vibrators at close enough intervals to vibrate and consolidate entire width of pavement uniformly. Mount mechanical vibrators to avoid contact with forms, reinforcement, transverse or longitudinal joints.

B. Furnish enough hand-manipulated mechanical vibrators for proper consolidation of concrete along forms, at joints and in areas not covered by mechanically controlled vibrators.

3.09 FINISHING

A. Finish concrete pavement with power-driven transverse finishing machines or by hand finishing methods.

1. Hand finish with mechanical strike and tamping template in same width as pavement to be finished. Shape template to pavement section shown on Drawings. Move strike template forward in direction of placement, maintaining slight excess of material in front of cutting edge. Make minimum of two trips over each area. Screed pavement surface to required section. Work screed with combined transverse and longitudinal motion in direction work is progressing. Maintain screed in contact with forms. Use longitudinal float to level surface.

B. On narrow strips and transitions, finish concrete pavement by hand. Thoroughly work concrete around reinforcement and embedded fixtures. Strike off concrete with strike-off screed. Move strike-off screed forward with combined transverse and longitudinal motion in direction work is progressing, maintaining screed in contact with forms, and maintaining slight excess of materials in front of cutting edge. Tamp concrete with

tamping template. Use longitudinal float to level surface.

C. After completion of straightedge operation, make first pass of burlap drag or transverse broom as soon as construction operations permit and before water sheen has disappeared from surface. Follow with as many passes as required to produce desired texture depth. Permit no unnecessary delays between passes. Keep drag wet, clean and free from encrusted mortar during use.

3.10 JOINTS AND JOINT SEALING

A. Conform to requirements of Section 02752 - Concrete Pavement Joints.

3.11 CONCRETE CURING

A. Conform to requirements of Section 02753 - Concrete Pavement Curing.

3.12 TOLERANCES

A. Test entire surface before initial set and correct irregularities or undulations. Bring surface within requirements of following test and then finish. Place 10-foot straightedge parallel to center of roadway to bridge depressions and touch high spots. Do not permit ordinates measured from face of straight edge to surface of pavement to exceed 1/16-inch per foot from nearest point of contact. Maximum ordinate with 10-foot straightedge shall not exceed 1/8-inch. Grind spots in excess of required tolerances to meet surface test requirements. Restore texture by grooving concrete to meet surface finishing specifications.

3.13 FIELD QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.

B. Compressive Strength Test Specimens: Make four test specimens for compressive strength test in accordance with ASTM C 31 for each 150 cubic yards or less of pavement that is placed in one day. Test two specimens at 7 days or at number of hours as directed by the Project Manager for high early strength concrete. Test remaining two specimens at 28 days. Test specimens in accordance with ASTM C 39. Minimum compressive strength shall be 3000 pounds per square inch for first two specimens and 3500 pounds per square inch at 28 days.

C. When compressive test indicates failure, make yield test in accordance with ASTM C 138 for cement content per cubic yard of concrete. When cement content is found to be less than that specified per cubic yard, increase batch weights until amount of cement per cubic yard of concrete conforms to requirements.

D. Minimum of one 4-inch core will be taken at random locations per 375-feet per 12-feet lane or 500 square yards of pavement to measure in-place depth. Measure depth in accordance with ASTM C 174. Each core may be tested for 28 day compressive strength

according to methods of ASTM C 42. 28 day compressive strength of each core tested shall be a minimum of 3000 pounds per square inch.

E. Request, at option, three additional cores in vicinity of cores indicating nonconforming in- place depths at no cost to City. In-place depth at these locations shall be average depth of four cores.

F. Fill cores and density test sections with new concrete paving or non-shrink grout.

3.14 NONCONFORMING PAVEMENT

A. Remove and replace areas of pavement found deficient in thickness by more than 10 percent, or that fail compressive strength tests, with concrete of thickness shown on Drawings.

B. When measurement of any core is less than specified thickness by more than 10 percent, actual thickness of pavement in this area will be determined by taking additional cores at 10-foot intervals parallel to centerline in each direction from deficient core until, in each direction, core is taken which is not deficient by more than 10 percent. Exploratory cores for deficient thickness will not be used in averages for adjusted unit price. Exploratory cores are to be used only to determine length of pavement in unit that is to be removed and replaced. Replace nonconforming pavement sections at no additional cost to City.

C. Remove and replace new pavement panels that do not have positive drainage and are not free of sitting water / ponding in the gutter ("gutter ponds") or on the pavement area of new panels. This requirement does not apply at the construction joint between existing pavement and a new individual panel that is properly installed to match the existing panel. However, this requirement applies between two new panels and within the area of new panels.

3.15 UNIT PRICE ADJUSTMENT

A. Unit price adjustments shall be made for in-place depth determined by cores as follows:

1. Adjusted Unit Price shall be ratio of average thickness as determined by cores to thickness bid upon, times unit price.

2. Apply adjustment to lower limit of 90 percent and upper limit of 100 percent of unit price.

3. Average depth below 90 percent but greater than 80 percent may be accepted by Project Manager at adjusted Unit Price of:

    a. Unit Price Bid - [2 x (1-ratio) x Unit Price Bid]

    b. Ratio equals average core thickness divided by thickness bid upon

c. 0.9 ratio pays 80 percent of unit price and 0.8 ratio pays 60 percent of unit price.

4. Average depth below 80 percent will be rejected by Project Manager.

3.16 PAVEMENT MARKINGS

A. Restore pavement markings to match those existing in accordance with City of Houston standard specifications and details and Project Manager's requirements.

3.17 PROTECTION

A. Barricade pavement section to prevent use until concrete has attained minimum design strength. Cure barricade pavement section for minimum 72 hours before use. Do not open pavement to traffic until concrete is at least 10 days old. Pavement may be open to traffic earlier provided Contractor pays for testing and additional specimen once 7 day specified strength is obtained. Pavement may be opened when high early strength concrete is used meeting specified 72 hour strength.

B. High early strength concrete may be used to provide access at driveways, street intersections, esplanades and other locations approved by Project Manager.

C. On those sections of pavement to be opened to traffic, seal joints, clean pavement, and place earth against pavement edges before permitting use by traffic. Opening of pavement to traffic shall not relieve responsibility for Work.

D. Maintain concrete paving in good condition until completion of Work.

E. Repair defects by replacing concrete to full depth.

END OF SECTION

SECTION 02752

CONCRETE PAVEMENT JOINTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Joints for concrete paving; concrete sidewalks, concrete driveways, curbs, and curb and gutters.

B. Saw-cutting existing concrete or asphalt pavements for new joints.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for street pavement expansion joints, with or without load transfer, is on linear foot basis.

2. Payment for horizontal dowels is on a unit price basis for each horizontal dowel.

3. No separate payment will be made for formed or sawed street pavement contraction joints and longitudinal weakened plane joints. Include payment in unit price for Concrete Paving.

4. No separate payment will be made for joints for Curb, Curb and Gutter, Saw-tooth Curb, Concrete Sidewalks, and Concrete Driveways. Include payment in unit price for Curb and Gutter, Concrete Sidewalks, and Concrete Driveways.

5. Payment will be made for Preformed Expansion Joints on a linear foot basis only when field conditions require that sidewalk be moved adjacent to existing concrete structure (i.e., street, back of curb, etc.).

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

B. ASTM D 994 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

C. ASTM D 1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

D. ASTM D 6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

E. TxDOT Tex-525-C - Tests for Asphalt and Concrete Joint Sealers

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for joint sealing compound and proposed sealing equipment for approval.

C. Submit samples of dowel cup, metal supports, and deformed metal strip for approval. Submit manufacturer's recommendation for placing sealant(s).

PART 2 PRODUCTS

2.02 BOARD EXPANSION JOINT MATERIAL

A. Filler board of selected stock. Use wood of density and type as follows:

1. Construction heart cypress weighing no more than 40 pounds per cubic foot, after being oven dried to constant weight.

2. Construction heart redwood weighing no more than 30 pounds per cubic foot, after being oven dried to constant weight.

2.03 PREFORMED EXPANSION JOINT MATERIAL

A. Bituminous fiber and bituminous mastic composition material conforming to ASTM D 994 and ASTM D 1751.

2.04 JOINT SEALING COMPOUND

A. Conform joint sealants to one of sealant classes described in this section.

B. Conform hot-poured rubber-asphalt compound to ASTM D 6690.

C. Two-component Synthetic Polymer.

1. Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles.

2. Cure sufficiently at average temperature of 25 ± 1 C (77 ± 2 F) so as not to pick up under wheels of traffic in maximum three hours.

3. Performance requirements, when tested in accordance with TxDOT Tex-525-C, shall meet above curing times and requirements as follows:

Cold-Extruded and Cold-Pourable (Self-Leveling) Specifications	
Property	**Requirement**
Penetration, 25 C (77 F) 150 g Cone, 5 s, 0.1 mm (in.), maximum	130
Bond and Extension 50%, -29 C (-20 F), 3 cycles: *Dry Concrete Block *Steel blocks (Primed, if recommended by manufacturer) *Steel blocks shall be used when armor joints are specified	 Pass Pass
Flow at 70 C (158 F)	None
Water content % by mass, maximum	5.0
Resilience: * Original sample, % min. (cured) * Oven-aged at 70 C (158 F), % min.	 50 50
Cold-extruded material only - Cold Flow (10 minutes)	None

After bond and extension test, there shall be no evidence of cracking, separation or other opening that is over 3 millimeters (1/8-inch) deep in sealer or between sealer and test blocks.

4. Provide cold-extruded type for vertical or sloping joints.

5. Provide self-leveling type for horizontal joints.

D. Self-Leveling, Low Modulus Silicone or Polyurethane Sealant for Asphaltic Concrete and Portland Cement Concrete Joints. This shall be a single component self-leveling silicone or polyurethane material that is compatible with both asphalt and concrete pavements. The sealer shall not require a primer for bond; a backer rod shall be required which is compatible with the sealant; no reaction shall occur between rod and sealant.

When tested in accordance with TxDOT Tex-525-C, self-leveling sealant shall meet following requirements:

Self-Leveling, Low Modulus Silicone or Polyurethane Sealant	
Property	**Requirements**
Tack Free Time, 25 ± 1 C (77 ± 2 F), minutes	120 maximum
Nonvolatile content, % by mass	93 minimum
Tensile Strength and 24 Hour Extension Test: * Initial, 10-day cure, 25 ± 1 C (77 ± 2 F), kPa (psi) * After Water Immersion, kPa (psi) * After Heat Aging, kPa (psi) * After Cycling, -29 C (-20 F), 50%, 3 cycles, kPa (psi) * 24 Hour Extension	 * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * Pass (All Specimens) After 24 hours, there shall be no evidence of cracking, separation or other opening that is over 3 mm (1/8 in.) deep at any point in the sealer or between the sealer and test blocks.

2.05 LOAD TRANSMISSION DEVICES

A. Smooth, steel dowel bars conforming to ASTM A 615, Grade 60. When indicated on Drawings, encase one end of dowel bar in approved cap having inside diameter 1/16-inch greater than diameter of dowel bar.

B. Deformed steel tie bars conforming to ASTM A 615, Grade 60.

2.06 SUPPORTS FOR REINFORCING STEEL AND JOINT ASSEMBLY

A. Employ supports of approved shape and size that will secure reinforcing steel and joint assembly in correct position during placing and finishing of concrete. Space supports as directed by Project Manager.

PART 3 EXECUTION

3.01 PLACEMENT

A. When new Work is adjacent to existing concrete, place joints at same location as existing joints in adjacent pavement.

B. If limit of removal of existing concrete or asphalt pavement does not fall on existing joint, saw cut existing pavement minimum of 2-inches deep to provide straight, smooth joint surface without chipping, spalling or cracks.

3.02 CONSTRUCTION JOINTS

A. Place transverse construction joint wherever concrete placement must be stopped for more than 30 minutes. Place longitudinal construction joints at interior edges of pavement lanes using No. 6 deformed tie bars, 30-inches long and spaced 18-inches on centers.

3.03 EXPANSION JOINTS

A. Place 3/4-inch expansion joints at radius points of curb returns for cross street intersections, or as located in adjacent pavement but no further than 80 feet apart. Use no boards shorter than 6 feet. When pavement is 24 feet or narrower, use not more than 2 lengths of board. Secure pieces to form straight joint. Shape board filler accurately to cross section of concrete slab. Use load transmission devices of type and size shown on Drawings unless otherwise specified or shown as "No Load Transfer Device." Seal with joint sealing compound.

3.04 CONTRACTION JOINTS

A. Place contraction joints at same locations as in adjacent pavement or at spaces indicated on Drawings. Place smoothed, painted and oiled dowels accurately and normal to joint. Seal groove with joint sealing compound.

3.05 LONGITUDINAL WEAKENED PLANE JOINTS

A. Place longitudinal weakened plane joints at spaces indicated on Drawings. If more than 15 feet in width is poured, longitudinal joint must be saw cut. Seal groove with joint sealing compound.

3.06 SAWED JOINTS

A. Use sawed joints as alternate to contraction and weakened plane joints. Use circular cutter capable of cutting straight line groove minimum of 1/4-inch wide. Maintain depth of one quarter of pavement thickness. Commence sawing as soon as concrete has hardened sufficiently to permit cutting without chipping, spalling or tearing and prior to initiation of cracks. Once sawing has commenced, continue until completed. Make saw cut with one pass. Complete sawing within 24 hours of concrete placement. Saw joints at required spacing consecutively in sequence of concrete placement.

B. Concrete Saw: Provide sawing equipment adequate in power to complete sawing to required dimensions and within required time. Maintain ample supply of saw blades at work site during sawing operations. Maintain sawing equipment on job during concrete placement.

3.07 TRANSVERSE WEAKENED PLANE JOINTS

A. Saw cut transverse contraction joints every 20-feet (nominally) in the pavement, but no greater than 20-feet between saw cuts. The spacing of the saw cuts shall be at regular intervals between expansion joints. The width of the saw cuts shall be a minimum of ¼-inch

wide, and the depth of the saw cuts shall be one-quarter of the pavement thickness. Commence saw cutting as soon as concrete has hardened sufficiently to allow saw cutting without damage to the pavement (affecting finish, chipping, spalling, tearing, etc.) and within 24 hours after concrete placement, but prior to initiation of cracks. Once sawing has commenced on a cut, continue until the cut is completed. Make each saw cut with one pass. Make saw cuts at required spacing consecutively in sequence of concrete placement. Seal the saw cuts (grooves) with joint sealing compound. The goal of the transverse saw cutting is to create weakened joints that will prevent random, non-linear, surface contraction cracking.

B. The dimension D/3 (but no less than 3-inches) on City of Houston Standard Drawing Number 02751-01 is measured from the bottom of the concrete slab.

C. Equipment requirements shall be in accordance with paragraph 3.06.B.

3.08 JOINTS FOR CURB, CURB AND GUTTER

A. Place 3/4-inch preformed expansion joints through curb and gutters at locations of expansion and contraction joints in pavement, at end of radius returns at street intersections and driveways, and at curb inlets. Maximum spacing shall be 120-foot centers.

3.09 JOINTS FOR CONCRETE SIDEWALKS

A. Provide 3/4-inch expansion joints conforming to ASTM A 1751 along and across sidewalk at back of curbs, at intersections with driveways, steps, and walls; and across walk at intervals not to exceed 36 feet. Provide expansion joint material conforming to ASTM D 994 for small radius curves and around fire hydrants and utility poles. Extend expansion joint material full depth of slab.

3.09 JOINTS FOR CONCRETE DRIVEWAYS

A. Provide 3/4-inch expansion joints conforming to ASTM D 1751 across driveway in line with street face of sidewalks, at existing concrete driveways, and along intersections with sidewalks and other structures. Extend expansion joint material full depth of slab.

3.10 JOINT SEALING

A. Seal joints only when surface and joints are dry, ambient temperature is above 50 degrees F and less than 85 degrees F and weather is not foggy or rainy.

B. Use joint sealing equipment in like new working condition throughout joint sealing operation, and be approved by Project Manager. Use concrete grooving machine or power-operated wire brush and other equipment such as plow, brooms, brushes, blowers or hydro or abrasive cleaning as required to produce satisfactory joints.

C. Clean joints of loose scale, dirt, dust and curing compound. The term joint includes wide joint spaces, expansion joints, dummy groove joints or cracks, either preformed or natural. Remove loose material from concrete surfaces adjacent to joints.

D. Fill joints neatly with joint sealer to depth shown. Pour sufficient joint sealer into joints so that, upon completion, surface of sealer within joint will be 1/4-inch above level of adjacent surface or at elevation as directed.

3.11 PROTECTION

A. Maintain joints in good condition until completion of Work.

B. Replace damaged joints material with new material as required by this Section.

END OF SECTION

SECTION 02753

CONCRETE PAVEMENT CURING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Curing of Portland cement concrete paving.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for concrete curing under this Section. Include payment in unit price for Concrete Paving, Concrete Sidewalks, Concrete Driveways, Curbs, and Curb and Gutters.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM C 156 - Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete.

B. ASTM C 171 - Standard Specifications for Sheet Materials for Curing Concrete.

C. ASTM C 309 - Standard Specifications for Liquid Membrane-Forming Compounds for Curing Concrete.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's product data for cover materials and liquid membrane-forming compounds.

PART 2 PRODUCTS

2.01 COVER MATERIALS FOR CURING

A. Conform curing materials to one of the following:

1. Polyethylene Film: Opaque pigmented white film conforming to requirements of ASTM C 171.

2. Waterproofed Paper: Paper conforming to requirements of ASTM C 171.

3. Cotton Mats: Single layer of cotton filler completely enclosed in cover of cotton cloth. Mats shall contain not less than 3/4 of a pound of uniformly distributed cotton filler per square yard of mat. Cotton cloth used for covering materials shall weigh not less than 6 ounces per square yard. Stitch mats so that mat will contact surface of pavement at all points when saturated with water.

2.02 LIQUID MEMBRANE-FORMING COMPOUNDS

A. Conform liquid membrane-forming compounds to ASTM C 309. Membrane shall restrict loss of water to not more than 0.55 kg/m^2 in 72 hours using test method ASTM C 156.

PART 3 EXECUTION

3.01 CURING REQUIREMENT

A. Cure concrete pavement by protecting against loss of moisture for period of not less than 72 hours immediately upon completion of finishing operations. Do not use membrane curing for concrete pavement to be overlaid by asphalt concrete.

B. Failure to provide sufficient cover material shall be cause for immediate suspension of concreting operations.

3.02 POLYETHYLENE FILM CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, apply water in form of fine spray. Cover surface with polyethylene film so film will remain in direct contact with surface during specified curing period.

B. Cover entire surface and both edges of pavement slab. Overlap joints in film sheets minimum of 12 inches. Immediately repair tears or holes occurring during curing period by placing acceptable moisture-proof patches or replacing.

3.03 WATERPROOFED PAPER CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, apply water in form of fine spray. Cover surface with waterproofed paper so paper will remain in direct contact with surface during specified curing period.

B. Prepare waterproofed paper to form blankets of sufficient width to cover entire surface and both edges of pavement slab, and not be more than 60 feet in length. Overlap joints in blankets caused by joining paper sheets not less than 5 inches and securely seal with asphalt cement having melting point of approximately 180 degrees F. Place blankets to secure overlap of at least 12 inches. Immediately repair tears or holes appearing in paper during curing period by cementing patches over defects.

3.04 COTTON MAT CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, completely cover surface with cotton mats, thoroughly saturated before application, maintaining contact with surface of pavement equally at all points.

B. Keep mats on pavement for specified curing period. Keep mats saturated so that, when lightly compressed, water will drip freely from them. Keep banked earth or cotton mat covering edges saturated.

3.05 LIQUID MEMBRANE-FORMING COMPOUNDS

A. Immediately after free surface moisture, and after concrete has dispersed, apply liquid membrane-forming compound in accordance with manufacturer's instructions.

B. Moisten concrete by water fogging prior to application of membrane when surface has become dry.

C. Seal concrete surface with single coat at rate of coverage recommended by manufacturer and directed by Project Manager, but not less than one gallon per 200 square feet of surface area.

3.06 TESTING MEMBRANE

A. Treated areas will be visually inspected for areas of lighter color of dry concrete as compared to dump concrete. Test suspected areas by placing few drops of water on surface. Membrane passes test when water stands in rounded beads or small pools which can be blown along surface of concrete without wetting surface.

B. Reapply membrane compound immediately at no cost to City when membrane fails above test.

END OF SECTION

SECTION 02767

THERMOPLASTIC PAVEMENT MARKINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This item includes the application of thermoplastic pavement markings, in conformance with the minimum optical and physical properties required for a thermoplastic road marking compound described herein, in a molten state, onto a pavement surface.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for thermoplastic pavement markings is on a linear foot basis.

2. Payment for words and symbols is for each word or symbol.

3. Payment for green colored pavement markings is on a square foot basis.

4. Payment for railroad crossing markings, to include stop line and two transverse lines, is for each crossing marked. For multi-lane approaches to railroad crossings, the solid 8-inch lines will be measured in linear feet, complete in place.

5. Unit price bid for each item shall be full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals necessary to complete Work in accordance with the plans and specifications.

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for work in the Section is included in total Stipulated Price.

1.03 MATERIAL

A. All materials shall conform to the requirements of TxDOT DMS-8220 "Hot Applied Thermoplastic." Thermoplastic materials shall be stored in a dry environment to minimize the amount of moisture retained during storage.

B. Materials used for green colored pavement (bicycle green) shall be manufactured with appropriate pigment to ensure that the resulting colors comply with the Light Green color as specified in the FHWA memorandum dated 4/15/2011: "Interim Approval for Optimal Use of Green Colored Pavement for Bike Lanes (IA-14)". Green colored pavement to be defined as transverse markings.

1.04 EQUIPMENT

A. Provide the necessary equipment to conduct the work specified herein. All equipment shall be maintained in good working order such that neat and clean thermoplastic markings are applied at the proper thicknesses and glass beads are placed at the correct rate. Equipment that is deemed deficient by the Engineer shall be replaced immediately.

PART 2 PRODUCTS

2.01 CONSTRUCTION

The appearance of the finished markings shall have a uniform surface, crisp edges with a minimum over-spray, clean cut-off, meet straightness requirements and conform to the design drawings and/or engineer instructions.

The contractor shall provide the Engineer with certification from the marking manufacturer that contractor has been adequately trained and certified to apply the manufacturer's material. This certification shall be considered current if the certification date provided by the manufacturer is within two years of the date of marking application.

All striping and pavement markings shall be placed in accordance with the requirements of this specification, the detailed plans, and the current edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD). The Contractor shall provide all other engineering services necessary for pre-marking of all proposed stripe within the limits of the designated work.

Unless authorized otherwise in writing by the Engineer, striping shall be accomplished during daylight hours. Approved lighting arrangements will be required for night time operations when allowed. The Contractor may be required to place markings over existing markings, as determined by the Engineer. The Contractor shall adjust the operation of the thermoplastic screed shoe to match the previous lengths of stripes and skips, when necessary.

Failure of the striping material to adhere to the pavement surface during the life of the contract shall be prima facie evidence that the materials, even though complying with these specifications, or the application thereof, was inconsistent with the intent of the requirements for the work under the latest City specifications and shall be cause for ordering corrective action or replacement of the marking without additional cost to the City.

Unless otherwise approved by the Engineer, permanent pavement markings on newly constructed pavements surfaced with asphaltic concrete or bituminous seals shall not be applied for a minimum of 14 days or a maximum 35 days. Temporary pavement marking shall be provided during the 14 to 35-day period.

A. Surface Preparation.

1. Moisture**.** All surfaces shall be inspected for moisture content prior to application of thermoplastic. Approximately two square feet of a clear plastic or tar paper shall be laid on the road surface and held in place for 15 to 20 minutes. The underside of the plastic or tar paper shall then be inspected for a buildup of condensed moisture from the road surface. Pavement is considered dry if there is no condensation on the underside of the plastic or tarpaper. In the event of moisture, this test shall be repeated until there is no moisture on the underside of the plastic or tar paper.

2. Cleaning. All surfaces shall be clean and dry, as defined in Section 535.4.A.1, before thermoplastic can be applied. Loose dirt and debris shall be removed by thoroughly blowing compressed air over the area to be striped. If the thermoplastic is to be applied over existing paint lines, the paint line shall be swept with a mechanical sweeper or wire brush to remove poorly adhered paint and dirt that would interfere with the proper bonding or the thermoplastic. Additional cleaning through the use of compressed air may be required to remove embedded dirt and debris after sweeping. Latence and curing compound shall be removed from all new Portland cement concrete surfaces in accordance with Section 02762, "Blast Cleaning of Pavement."

3. Layout. The pavement markings shall be placed in proper alignment with guidelines established on the roadway. Deviation from the alignment established shall not exceed 2 inches and, in addition, the deviation in alignment of the marking being placed shall not exceed 1 inch per 200 feet of roadway nor shall any deviation be abrupt.

   No striping material shall be applied over a guide cord; only longitudinal joints, existing stripes, primer, or other approved type guides will be permitted. In the absence of a longitudinal joint or existing stripe, the Contractor shall mark the points necessary for the placing of the proposed stripe. Edge striping shall be adjusted as necessary so that the edge stripe will be parallel to the centerline and shall not be placed off the edge of the pavement.

   Longitudinal markings shall be offset at least 2-inches from construction joints of Portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

4. Primer Sealer. Primer sealer shall be used on all Portland cement concrete surfaces. A primer sealer shall be used on asphalt surfaces that are over two years old and/or on asphalt surfaces that are worn or oxidized to a condition where 50 percent or more of the wearing surface is exposed aggregate. Existing pavement markings may act as the primer sealer if, after cleaning, more than 70 percent of the existing pavement marking is still properly bonded to the asphalt surface.

5. Primer Sealer Application. When required as described, the primer-sealer shall be applied to the road surface in a continuous film at a minimum thickness of 3 to 5 mils. Before the Thermoplastic is applied, the primer-sealer shall be allowed to dry to a tacky state. The thermoplastic shall be applied within 4 hours after the primer application.

B. Temperature Requirements.

1. Ambient Conditions. The ambient air and road surface shall be 55°F and rising before application of thermoplastic can begin.

2. Material Requirements. Unless otherwise specified by the material manufacturer, the thermoplastic compound shall be heated from 400°F to 450°F and shall be a minimum of 400°F as it makes contact with road surface during application. An infrared temperature gun shall be used to determine the temperature of the thermoplastic as it is being applied to the road surface.

C. Drop-on Glass Sphere Application.

1. Application Rate. Retro-reflective glass spheres shall be applied at the rate of 10 pounds per 100 square feet of applied markings. This application rate shall be determined by confirming the following consumption rates:

a. 200 pounds of drop on glass spheres per ton of applied thermoplastic when the thermoplastic is being applied at 0.090 inch film thickness.

b. 150 pounds of drop on glass spheres per ton of applied thermoplastic when the thermoplastic is being applied at 0.125 inch thickness.

2. Application Method. Retro-reflective glass spheres shall be applied by a mechanical dispenser property calibrated and adjusted to provide proper application rates and uniform distribution of the spheres across the cross section of the entire width of the line. To enable the spheres to embed themselves into the hot thermoplastic, the sphere dispenser shall be positioned immediately behind the thermoplastic application device. This insures that the spheres are applied to the thermoplastic material while it is still in the molten state.

D. Application Thickness.

1. Longitudinal and Transverse Markings. On previously unmarked pavements or pavements where markings have been effectively removed, all lane lines, center lines, transverse markings and pavement markings in traffic areas with :S 1 ,000 vehicles per day per lane shall have a minimum film thickness of 0.090 inch at the edges and a maximum of 0.145 inch at the center. A minimum average film thickness of 0.090 inch shall be maintained. On pavements with existing markings, meeting the traffic requirements stated above, all lane lines, center lines, transverse markings and pavement markings shall have a minimum

film thickness of 0.060 inch for re-application over existing strip line.

2. High Wear Longitudinal and Transverse Marking. On previously unmarked pavements or pavements where markings have been effectively removed, all lane lines, center lines, transverse markings and pavement markings in high traffic areas (>1,000 vehicles per day per lane) shall have a minimum film thickness of 0.125 inch at the edges and a maximum of 0.188 inch at the center. A minimum average film thickness of 0.125 inch shall be maintained. On pavements with existing markings, meeting the traffic requirements stated above, all lane lines, center lines, transverse markings and pavement markings shall have a minimum film thickness of 0.090 inch for re-application over existing strip line.

E. Packaging.

1. Containers. The thermoplastic material shall be delivered in 50 pound containers or bags of sufficient strength to permit normal handling during shipment and handling on the job without loss of material.

2. Labeling. Each container shall be clearly marked to indicate the color of the material, the process batch number and/or manufacturer's formulation number, the manufacturer's name and address and the date of manufacture.

F. Acceptance.

1. Sampling Procedure. Random samples may be taken at the job site at the discretion of the City Traffic Engineer for quality assurance. The City reserves the right to conduct the tests deemed necessary to identify component materials and verify results of specific tests indicated in conjunction with the specification requirements.

   The sample(s) shall be labeled as to the shipment number, lot number, date, quantity, and any other pertinent information. At least three randomly selected bags shall be obtained from each lot. A 10 pound) sample from the three bags shall be submitted for testing and acceptance. The lot size shall be approximately 44,000 pounds unless the total order is less than this amount.

2. Manufacturer's Responsibility.

   a. Sampling and Testing. The manufacturer shall submit test results from an approved independent laboratory. All material samples shall be obtained 20 days in advance of the pavement marking operations. The cost of testing shall be included in the price of thermoplastic material. The approved independent laboratory's test results shall be submitted to the City Traffic Engineer in the form of a certified test report.

b. Bill of Lading. The manufacturer shall furnish the Material and Tests Laboratory with copies of Bills of Lading for all materials inspected. Bill of lading shall indicate the consignee and the destination, date of shipment, lot numbers, quantity, type of material, and location of source.

c. Material Acceptance. Final acceptance of a particular lot of thermoplastic will be based on the following.

(1) Compliance with the specification for material composition requirements verified by approved independent laboratory with tests results.

(2) Compliance with the specification for the physical properties required and verified by an approved independent laboratory with test results.

(3) Manufacturer's test results for each lot thermoplastic have been received.

(4) Identification requirements are satisfactory.

3. Contractor's Responsibility.

a. Notification. The contractor shall notify the Construction Inspector 72 hours prior to the placement of the thermoplastic markings to enable the inspector to be present during the application operation. At the time of notification, the Contractor shall indicate the manufacturer and the lot numbers of the thermoplastic that will be used.

A check should be made by the contractor to ensure that the approved lot numbers appear on the material package. Failure to do so is cause for rejection.

b. Warranty or Guarantee. If the normal trade practice for manufacturers is to furnish warranties or guarantees for the materials and equipment specified herein, the Contractor shall turn the guarantees and warranties over to the Engineer for potential dealing with the manufacturers. The extent of such warranties or guarantees will not be a factor in selecting the successful bidder.

PART 3 EXECUTION – Not Used

END OF SECTION

SECTION 02771

CURB, CURB AND GUTTER, AND HEADERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced concrete curb, reinforced monolithic concrete curb and gutter, and mountable curb.

B. Paving headers and railroad headers poured monolithically with concrete base or pavement.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for curbs, curbs and gutter, and esplanade curbs is on linear foot basis measured along face of curb.

2. Payment for 3-foot concrete valley gutter is on a linear foot basis.

3. Payment for mountable concrete curbs is on a square foot basis.

4. Payment for concrete paving headers and concrete railroad headers is on a linear foot basis.

5. Payment for headers is on linear foot basis measured between lips of gutters adjacent to concrete base and measured between backs of curbs adjacent to concrete pavement.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit details of proposed form work for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements for welded wire fabric of Section 02751 - Concrete Paving.

C. Grout: Nonmetallic, non-shrink grout containing no chloride producing agents conforming to following requirements.

1. Compressive strength

a. at 7 days: 3500 psi

b. at 28 days: 8000 psi

2. Initial set time: 45 minutes

3. Final set time: 1.5 hours

D. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

E. Expansion Joint Filler: Conform to material requirements for expansion joint filler of Section 02752 - Concrete Pavement Joints.

F. Mortar: Mortar finish composed of one part Portland cement and 1 1/2 parts of fine aggregate. Use only when approved by Project Manager.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare subgrade in accordance with applicable portions of sections on excavation and fill, embankment, and subgrade and roadbed.

3.02 PLACEMENT

A. Guideline: Set to follow top line of curb. Attach indicator to provide constant comparison between top of curb and guideline. Ensure flow lines for monolithic curb and gutters conform to slopes indicated on Drawings.

B. Forms: Brace to maintain position during pour. Use metal templates cut to section shown on Drawings.

C. Reinforcement: Secure in position so that steel will remain in place throughout placement. Reinforcing steel shall remain at approximate center of base or pavement as indicated on Drawings.

D. Joints: Place in accordance with Section 02752 - Concrete Pavement Joints. Place dummy groove joints at to match concrete pavement joints at right angles to curb lines. Cut dummy grooves 1/4-inch deep using approved edging tool.

E. Place concrete in forms to required depth. Consolidate thoroughly. Do not permit rock pockets in form. Entirely cover top surfaces with mortar.

3.03 MANUAL FINISHING

A. After concrete is in place, remove front curb forms. Form exposed portions of curb, and of curb and gutter, using mule which conforms to curb shape, as shown on Drawings.

B. Thin coat of mortar may be worked into exposed face of curb using mule and two-handled wooden darby at least 3 feet long.

C. Before applying final finish move 10 foot straightedge across gutter and up curb to back form of curb. Repeat until curb and gutter are true to grade and section. Lap straightedge every 5 feet.

D. Steel trowel finish surfaces to smooth, even finish. Make face of finished curb true and straight.

E. Edge outer edge of gutter with 1/4-inch edger. Finish edges with tool having 1/4 inch radius.

F. Finish visible surfaces and edges of finished curb and gutter free from blemishes, form marks and tool marks. Finished curb or curb and gutter shall have uniform color, shape and appearance.

3.04 MECHANICAL FINISHING

3.05 Mechanical curb forming and finishing machines may be used instead of, or in conjunction with, previously described methods, when approved by Project Manager. Use of mechanical methods shall provide specified curb design and finish.

3.06 CURING

A. Immediately after finishing operations, cure exposed surfaces of curbs and gutters in accordance with Section 02753 - Concrete Pavement Curing.

3.07 TOLERANCES

A. Top surfaces of curb and gutter shall have uniform width and shall be free from humps, sags or other irregularities. Surfaces of curb top, curb face and gutter shall not vary more than 1/8 inch from edge of straightedge laid along them, except at grade changes.

3.08 PROTECTION

A. Maintain curbs and gutters in good condition until completion of Work.

B. Replace damaged curbs and gutters to comply with this Section.

END OF SECTION

SECTION 02772

CONCRETE MEDIANS AND DIRECTIONAL ISLANDS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete medians and directional islands.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete medians and directional islands is on square yard basis measured from back of curbs.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements for welded wire fabric of Section 02751 - Concrete Paving.

C. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

D. Expansion Joint Filler: Conform to material requirements for expansion joint filler of Section 02752 - Concrete Pavement Joints.

E. Subgrade Materials: Conform to subgrade material requirements of Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade and Section 02338 - Portland Cement Stabilized Subgrade.

PART 3 EXECUTION

3.01 SUBGRADE

A. Prepare subgrade in accordance with applicable portions of sections on excavation and fill and embankment. Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade and Section 02338 - Portland Cement Stabilized Subgrade.

3.02 PLACEMENT OF CONCRETE

A. Place and finish concrete in accordance with applicable portions of Section 02751 - Concrete Paving.

3.03 JOINTS

A. Install joints in accordance with Section 02752 - Concrete Pavement Joints.

3.04 CONCRETE CURING

A. Cure concrete in accordance with Section 02753 - Concrete Pavement Curing.

3.05 PROTECTION

A. Maintain concrete medians and directional islands in good condition until completion of work.

B. Replace damaged concrete medians and directional islands to comply with this Section.

END OF SECTION

SECTION 02775

CONCRETE SIDEWALKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced concrete sidewalks.

B. Wheelchair ramps.

C. Reinforced slope paving.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete sidewalks is on square foot basis.

2. No payment will be made for work outside these limits or in areas where driveway has been removed or replaced for Contractor's convenience.

3. Payment for wheelchair ramps of each type specified is on square foot basis. Removal and replacement of existing sidewalk, curb or curb and gutter and saw-cutting is paid by unit cost for each item. Sodding will be paid one foot on each side of sidewalk unless otherwise noted. Staining of wheelchair ramps is included in cost of ramp.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in Field.

B. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

C. ASTM C 42 - Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

D. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

E. ASTM C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.

F. ASTM C 172 - Standard Practice for Sampling Freshly Mixed Concrete.

G. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3).

H. Texas Accessibility Standards of Architectural Barriers Act, Article 9102, Texas Civil Statues.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certified testing results and certificates of compliance.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements of Section 02751 - Concrete Paving for reinforcing steel. Use No. 3 reinforcing bars.

C. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

D. Expansion Joint Filler: Conform to material requirements for expansion joint material of Section 02752 - Concrete Pavement Joints.

E. Forms: Use straight, unwarped wood or metal forms with nominal depth equal to or greater than proposed sidewalk thickness. The use of 2 inch by 4 inch lumber as forms will not be allowed.

F. Sand Bed: Conform to material requirements for bank run sand of Section 02320 - Utility Backfill Materials.

G. Sodding: Conform to material requirements for sodding of Section 02922 - Sodding.

H. Coloring for wheelchair ramps: Conform to material requirements for colored concrete of Section 02761 - Colored Concrete for Medians and Sidewalks. Color shall be Brick Red or as shown on the drawings.

PART 3 EXECUTION

3.01 REPLACEMENT

A. Replace sidewalks and slope paving which are removed or damaged during construction with thickness and width equivalent to one removed or damaged, unless otherwise shown on Drawings. Finish surface (exposed aggregate, brick pavers, etc.) to match existing sidewalk.

B. Provide replaced and new sidewalks with wheelchair ramps when sidewalk intersects curb at street or driveway.

3.02 PREPARATION

A. Identify and protect utilities which are to remain.

B. Protect living trees, other plant growth, and features designated to remain.

C. Conduct clearing and grubbing operations in accordance with Section 02233 - Clearing and Grubbing.

D. Excavate subgrade 6 inches beyond outside lines of sidewalk. Shape to line, grade and cross section. For soils with plasticity index above 40 percent, stabilize soil with lime in accordance with Section 02336 – Lime-Stabilized Subgrade. Compact subgrade to minimum of 90 percent maximum dry density at optimum to 3 percent above optimum moisture content, as determined by ASTM D 698.

E. Immediately after subgrade is prepared, cover with compacted sand bed to depth as shown on Drawings. Lay concrete when sand is moist but not saturated.

3.03 PLACEMENT

A. Setting Forms: Straight, unwarped wood or metal forms with nominal depth equal to or greater than proposed sidewalk thickness. Use of 2 by 4's as forms will not be allowed. Securely stake forms to line and grade. Maintain position during concrete placement.

B. Reinforcement:

1. Install reinforcing bars.

2. Install reinforcing steel as shown on the drawings. Lay longitudinal bars in walk

continuously, except through expansion joints.

3. Use sufficient number of chairs to support reinforcement in manner to maintain reinforcement in center of slab vertically during placement.

4. Drill dowels into existing paving, sidewalk and driveways, secure with epoxy, and provide headers as required.

5. Use sufficient number of chairs for steel reinforcement bars to maintain position of bars within allowable tolerances. Place reinforcement as shown on Drawings. In plane of steel parallel to nearest surface of concrete, bars shall not vary from plan placement by more than 1/12 of spacing between bars. In plane of steel perpendicular to nearest surface of concrete, bars shall not vary from plan placement by more than 1/4 inch.

C. Expansion Joints: Install expansion joints with load transfer units in accordance with Section 02752 - Concrete Pavement Joints.

E. Place concrete in forms to specified depth and tamp thoroughly with "jitterbug" tamp, or other acceptable method. Bring mortar to surface.

F. Strike off to smooth finish with wood strike board. Finish smoothly with wood hand float. Brush across sidewalk lightly with fine-haired brush.

G. Apply coating to wheelchair ramp with contrasting color in accordance with Section 02761 - Colored Concrete for Medians and Sidewalks.

H. Unless otherwise indicated on Drawings, mark off sidewalk joints 1/8 inch deep, at spacing equal to width of walk. Use joint tool equal in width to edging tool.

I. Finish edges with tool having 1/4 inch radius.

J. After concrete has set sufficiently, refill space along sides of sidewalk to one-inch from top of walk with suitable material. Tamp until firm and solid, place sod as applicable. Dispose of excess material in accordance with Section 01576 - Waste Material Disposal. Repair driveways and parking lots damaged by sidewalk excavation in accordance with Section 02951 - Pavement Repair and Restoration.

3.04 CURING

A. Conform to requirements of Section 02753 - Concrete Pavement Curing.

3.05 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Compressive Strength Test Specimens: Four test specimens for compressive strength test will be made in accordance with ASTM C 31 for each 30 cubic yards or less of sidewalk that is placed in one day. Two specimens will be tested at 7 days. Remaining two specimens will be tested at 28 days. Specimens will be tested in accordance with ASTM C 39. Minimum compressive strength: 3000 psi at 7 days and 3500 psi at 28 days.

C. Yield test for cement content per cubic yard of concrete will be made in accordance with ASTM C 138. When cement content is found to be less than that specified per cubic yard, reduce batch weights until amount of cement per cubic yard of concrete conforms to requirements.

D. If the Contractor places concrete without notifying the laboratory, the City will have the concrete tested by means of core test as specified in ASTM C 42. When concrete does not meet specification, cost of test will be deducted from payment.

E. Sampling of fresh concrete shall be in accordance with ASTM C 172.

F. Take slump tests when cylinders are made and when concrete slump appears excessive.

G. Concrete shall be acceptable when average of two 28 day compression tests is equal to or greater than minimum 28 day strength specified.

H. If either of two tests on field samples is less than average of two tests by more than 10 percent, that entire test shall be considered erratic and not indicative of concrete strength. Core samples will be required of in-place concrete in question.

I. If 28 day laboratory test indicates that concrete of low strength has been placed, test concrete in question by taking cores as directed by Project Manager. Take and test at least three representative cores as specified in ASTM C 42 and deduct cost from payment due.

3.06 NONCONFORMING CONCRETE

A. Remove and replace areas that fail compressive strength tests, with concrete of thickness shown on Drawings.

B. Replace nonconforming sections at no additional cost to City.

3.07 PROTECTION

A. Maintain newly place concrete in good condition until completion of Work.

B. Replace damaged areas.

END OF SECTION

SECTION 02893

TRAFFIC SIGNAL CONSTRUCTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification consists of the requirements to construct traffic signals in the City of Houston.

1.02 UNIT PRICES

A. Unit Prices

Items discussed in this specification shall be measured separately from the unit price items identified in Document 00410 – Schedule or Unit Price Work. Items and work processes discussed in this section are incidental to furnishing and installing a functioning traffic signal.

No separate payment shall be made for Traffic Signal Construction under this Section. Payment will be included under various unit price items included in Document 00410 – Schedule of Unit Price Work.

1. Measurement and payment of traffic signal items shall be per each unit furnished and installed complete and in place with all appurtenances.

2. Payment for traffic control devices will be on the basis of each device installed as shown on the drawings or as directed by the City Engineer and/or the approved City of Houston Representative.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price per Intersection (Lump Sum)
If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 SPECIAL REQUIREMENTS

The requirements of this contract encompass the construction of new traffic signal installations either installed 1.) concurrent with the street or roadway improvement phases of the work so that the signals will be in operation at the time the intersection is open to traffic, or 2.) as traffic signal or traffic signal related improvements.

The purpose and intent of this specification is for the Contractor to furnish all labor,

materials, tools, equipment, tests, adjustments and all other incidentals necessary to install and/or modify a traffic signal system. The Contractor shall also install items furnished by the City of Houston, specified herein. All materials and equipment furnished for installation under this contract shall be new and unused, unless otherwise specified. Contractor shall furnish and install or install materials as specified herein.

All bidders shall visit the job site prior to bidding in order to acquaint themselves with all job site conditions and problems, if any, and all other factors that may affect the bid on all project specific contracts. On work order type projects, all bidders shall thoroughly familiarize themselves with City of Houston requirements and general field conditions. Any discrepancy between drawings and specifications shall be resolved prior to bidding.

These specifications together with the reference Drawings and Contract Documents require the furnishings of all superintendence, labor, tools, equipment and apparatus necessary for the complete working system of the traffic signal installation(s). All submittals need to be pre-approved prior to the job and by the inspector as directed by the Engineer and/or the approved City of Houston Representative.

Email Traffic Signal Engineering and Operations, (citytrafficprojmgr@houstontranstar.org) for coordination and inspection of traffic signal work. Contractor is required to notify daily activities to City Traffic Signal Inspector via email (citytrafficinspector@houstontranstar.org) before 7:30 A.M.

All control equipment shall confirm to ITE and NEMA specifications and in accordance with the drawings and specifications.

All construction will be in accordance with the Texas Manual on Uniform Traffic Control Devices, latest revisions, and in accordance with the drawings and specifications.

All wiring throughout each traffic signal installation shall be in strict accordance with the National Electric Code, all local applicable codes and shall also comply with all requirements of CenterPoint Energy, in order that service may be obtained from them. All costs for code compliance are to be included in the bid for this contract.

1.04 REFERENCES

A. References: References to known standard specifications in the Specification shall mean and intend latest edition of such specification adopted and published at date of invitation to submit Proposals.

B. Reference to technical society, organization or body is made in Specifications in accordance with the following abbreviations:

	AASHO	American Association of State Highway Officials
	ACI	American Concrete Institute
*	AIEE	American Institute of Electrical Engineers

	AISC	American Institute of Steel Construction
	AISI	American Iron and Steel Institute
	ASA	American Standards Association
	ASTM	American Society for Testing and Materials
	AWSC	American Welding Society Code
	FS	Federal Specification
	IMSA	International Municipal Signal Association
	IPCEA	Insulated Power Cable Engineers Association
	ITE	Institute of Traffic Engineers
	MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
	NBFU	National Board of Fire Underwriters
	NBS	National Bureau of Standards
	NEC	National Electrical Code
	NEMA	National Electrical Manufacturers Association
	OSHA	Occupational Safety and Health Association
	UL	Underwriters' Laboratories
*	IEEE	Institute of Electrical and Electronics Engineers - name changed from AIEE & IRE (Institute of Radio Engineers)

1.05 PERMITS, LAWS, CODES, ETC.

The contractor and subcontractors shall comply with all Federal, State and local Laws, Codes and Ordinances applicable to the work and all requirements of the National board of Fire Underwriters having jurisdiction. If the above laws, codes or ordinances conflict with specification, then the laws, codes or ordinances shall govern except where Specification exceeds them in quality of quantity of materials or labor. Obtain and pay for all permits required in connection with the execution of the work as required. The Engineer and/or the approved City of Houston Representative shall be furnished with certified copies of these permits if requested.

1.06 COOPERATION WITH BUILDING OFFICIALS

Cooperate with local and other governmental officials and inspectors at all times. If such official or inspector deems special inspection necessary, provide assistance and facilities that will expedite their inspection. Any materials and or workmanship which are rejected by the Traffic Signal Inspector by reason of failure to conform to the requirements of the drawings or specifications, shall be removed and replaced by the contractor at their own expense.

1.07 SUBSTITUTIONS

A. Except in special instances, the Technical Sections of these specifications list more than one manufacturer of the products specified. Products of listed manufacturers conform basically to design and performance requirements as indicated on the Drawings and specified herein and Contractor in proposing their use shall indicate by

detail drawings and/or descriptive data any modifications of items or assemblies necessary to provide the indicated and/or specified work.

B. Requests for substitutions of materials must be submitted in writing to the Engineer and/or the approved City of Houston Representative by the Contractor. These substitutions will only be considered if fewer than three manufacturers are listed in the Specifications.

C. Under no circumstances will the Engineer and/or the approved City of Houston Representative be required to provide that a product proposed for substitution is, or is not, of equal quality to the product specified. It is mandatory that the Contractor submit to the Engineer and/or the approved City of Houston Representative, in Writing, all evidence necessary to support this contention that the item proposed for substitution is equal to the item indicated by the Contract Documents. Items submitted for substitution must be submitted one month prior to bid opening.

1.08 MANUFACTURER'S SPECIFICATION AND INSTRUCTIONS

Install all manufactured items, materials and equipment in strict accordance with the manufacturer's recommended specifications except that the Specifications herein, where more stringent, shall be complied with.

1.09 MEASUREMENTS

Before doing any work or ordering any materials, the Contractor and Subcontractors shall verify all measurements of existing and new work and shall be responsible for their correctness. Any difference which may be found shall be submitted to the Engineer and/or the approved City of Houston Representative for consideration before proceeding with the work. No extra compensation will be allowed because of differences between actual dimensions and measurements indicated on the drawings.

1.10 RECORD DRAWINGS

Provide and maintain in proper order and in good, clean condition at the project sites, one complete set of prints of all project drawings. On this set of drawings, the Contractor shall neatly print and accurately inscribe, in red pencil, any and all changes or deviations from construction and installation as originally indicated in the plans and specifications. This set of prints shall be delivered to City of Houston Traffic Management and Maintenance at TranStar Third Floor, 6922 Old Kay Road, at the time of final acceptance of the work by the City in order to provide the City with an “AS BUILT” set of plans.

1.11 TEMPORARY FACILITIES

A. Weather Protection

1. Contractor shall at all times provide protection against weather, so as to maintain all work, materials, apparatus, and fixtures free from injury and damages. At the

end of the day's work, all new work likely to be damaged shall be covered or otherwise protected.

2. Wet work shall not be performed when temperature is below 40˚ F, or is likely to go below 40˚ F, within the ensuing 48 hours, except when sufficient protective heat is provided and the Engineer's and/or the approved City of Houston Representative's approval in writing is obtained.

3. Contractor shall construct and maintain all necessary temporary drainage and do all pumping necessary to keep excavations, pits and trenches free of water.

B. Operation of Equipment

When electrical or other equipment is installed, it shall be the responsibility of the Contractor to check out same for a period of time as required by the Engineer and/or the approved City of Houston Representative for proper testing of the equipment. All items of equipment,testing instruments and incidentals necessary for proper testing of equipment shall be furnished by Contractor.

C. When any temporary facility is no longer needed for the proper conduct of the work as determined by the Engineer and/or the approved City of Houston Representative, the Contractor shall completely remove it from the project and shall repair or replace all material, equipment and finished surfaces damaged in doing so.

D. Contractor shall provide a portable toilet as needed.

1.12 PROTECTION

Provide barricades, fences, lights, etc., for protection of property and the public as required by local and/or State Ordinances. Contractor will be held liable for all damage to property and/or persons.

A. All barricades and signs shall conform to Texas MUTCD. Such barricades and protective signs shall be provided by the Contractor at their expense.

B. Flow of traffic shall not be interrupted completely without the approval of the Engineer and/or the approved City of Houston Representative. Restriction and minor diversion will be kept to a minimum. No work will be permitted in the traffic lanes during peak hours from **7:00 to 9:00 AM and 4:00 to 6:00 PM Monday through Friday**. Any open cuts in the intersections during these hours will be covered with steel plates to maintain uninterrupted traffic.

C. Flagmen shall be certified flagmen or off-duty uniformed peace officers of the law. Contractor shall provide flagmen to direct traffic when directed bythe Area Engineer and/or the approved City of Houston Representative of the Traffic Management and Maintenance Division. This does not relieve Contractor of responsibility of taking other steps and providing other personnel who he may deem necessary for protection

of work and public.

D. Appropriate Personal Protective Equipment shall be worn by all contract personnel when on the job-site.

1.13 RESTORING DAMAGED AREAS

For all work at identified intersections and along communication cable routing, in the event that sidewalks, pavement, curbs, wheelchair ramps, driveways, landscaped areas, areas with special pavement treatment, sprinkler systems, lighting systems, or other items or properties both public and private that are damaged during this construction, shall be restored to their prior condition without expense to the City of Houston. No separate payment will be made for the restoration of these items.

Where signal poles are installed inside the existing 4 foot sidewalk or within 12 inches of either side of the existing sidewalk, the Contractor shall provide a minimum of 4 foot paved sidewalk 12 inches away from edge of the signal pole. The horizontal slope for the sidewalk shall be 2 percent.

PART 2 PRODUCTS

2.01 MATERIALS

Contractor is responsible for furnishing all materials and labor for construction of items as shown on drawings and other incidentals necessary to provide a fully operational traffic control signal. The Contractor shall furnish and install all materials, with exception of materials to be provided by the City of Houston.

Material should be installed according to the technical specifications and standard details under the direction of the City of Houston representative assigned to the project.

In addition to all items to be furnished and installed by the Contractor, the Contractor shall furnish and install all items necessary for the complete signal system including but not limited to the following incidental materials:

All conduit nipples, couplings, grounding bushings, elbows, sweeps and service heads.
All reinforcing steel and ties.
Concrete, sand, cement, gravel, asphalt, earth fill.
Span guy, down guys, anchor rod assemblies.
Sidewalk guy assemblies (if necessary).
Guy guards, three bolts clamps, lag screws.
5/8” Thru-bolts, nuts, washers, thimble-eye nuts and bolts.
5/16” Stranded galvanized steel cable for guys and catenaries.
¼” Stranded galvanized steel cable for messengers.
Strand vises and links as needed.
Meter loop assemblies complete.
Signal mounting harware.

Copperweld ground rods and clamps furnished and installed in all foundations and each pullbox.
Flexible stainless steel cable strap ties. Cable ties shall be Panduit Part #MLT 4H-LP or equivalent.
#6 or #8 Soft bare copper wire for grounding poles, conduits, etc.
Miscellaneous hardware.

Interconnect cable shall be communications grades as follows:
Type PE-38 or PE-22 (aerial)
Type PE-39 (underground)

All proposed changes in the signalization plan must be submitted to the City of Houston, in writing, for approval.

The Contractor shall be responsible for the protection of all present utilities that have been located by the various utility companies. They shall also maintain and protect the existing traffic signals and their related equipment from damage caused by subcontractors and employees under the Contractor's Contract but only to the extent of the Contractor's normal work operation, and the Contractor shall not be responsible for routine maintenance, normal wear and tear, or an act of God, unless otherwise specified.

The contractor shall bag all newly installed signal heads and/or pedestrian signal heads with burlap until final inspection and acceptance by the City of Houston Representative. The signal shall be wrapped with burlap at least twice so that the entire signal head is covered, and cannot be seen until it is placed in operation. The signal shall be de- energized while not in use. If, in the opinion of the Engineer and/or the approved City of Houston Representative, the new heads would create a hazard condition to motorists and/or pedestrians, the heads shall not be installed until one hour before turning on the new equipment.

All existing traffic signal equipment removed by the Contractor shall be tagged to identify location. A representative of Traffic Signal Engineering and Operations shall be given **24 hour** notice before delivery of an approval location by the Engineer and/or the approved City of Houston Representative. Equipment not identified will not be accepted and equipment not returned will result in the withholding of payment to the Contractor. Traffic Signal Engineering and Operations personnel will issue a receipt to Contractor for returned equipment.

When the City Traffic Engineer and/or the approved City of Houston Representative determines that the need for a traffic signal is critical to the public welfare, early "turn on" of the signal shall be required before the completion of the project. If the need arises, the City of Houston will assume the responsibility for maintenance and liability, or negotiate with the Contractor for maintenance and liability for such a signal.

The City Traffic Engineer and/or the approved City of Houston Representative may, at any time, authorize City of Houston personnel to enter the controller cabinet in order to restore any and all signal equipment to proper operation if the malfunction or non- function of such

equipment poses a hazard or inconvenience to motorists or pedestrians. Such authorized entry may occur at any time within the period of the Contract and such authorized entry shall in no way relieve the Contractor or manufacture of their respective warranties.

During the burn-in period, the Contractor shall restore operation of the installation within **four (4) hours** after notification of a malfunction. If the Contractor does not respond within **four (4) hours**, the City of Houston shall have the option of making the necessary repair and billing the Contractor for the actual time and materials required.

When replacing sidewalks or curb and gutters, it shall be the responsibility of the Contractor to reinstall them to match existing color and/or surface texture.

Materials specified herein shall be installed as per Traffic and Transportation Construction Details drawings-02893 series and the City of Houston Traffic Signal Standard Specifications.

The Contractor shall be responsible for having an authorized manufacturer representative of traffic control equipment present as per the requirements of Specification Section 01755, "STARTING SYSTEMS".

Each work order or intersection shall be a stand alone "Turn Key Job" by the Contractor.

A steel template of the proper dimensions shall be furnished and used by the Contractor to secure anchor bolts while constructing pole foundations.

Flexible stainless steel cable ties for strapping signal cable to messenger shall be min: 13.38-inches long, 120 lb. min. tensile holding strength, 3/16-inch to 3-1/2-inches wire bundle range. (Panduit Part #MLT 4H-LP or approved equal).

2.02 PRECONSTRUCTION MEETING

The Traffic & Transportation Division for Traffic Signal Contracts shall schedule a Preconstruction Meeting at TranStar after award of contract and prior to commencement of construction. The Contractor or the Contractor's authorized representative will be required to attend.

For roadway contracts, the preconstruction meeting for the traffic signal work shall be coordinated by the roadway project manager.

2.03 MATERIALS FURNISHED BY THE CITY

Prior to material pick up, a written notice is required sixty (60) calendar days in advance. This letter shall be addressed to:

City of Houston - Traffic Signal Engineering & Operations
Traffic & Transportation Division
6922 Old Katy Road (Houston TranStar)
Houston, Texas 77024

Materials furnished by the City shall be picked up **by the Contractor at the Traffic Operations Center, 2200 Patterson Street, Houston, Texas 77007, after giving a minimum of two (2) working days notice to the City of Houston by emailing to: (citytrafficprojmgr@houstontranstar.org) . This is in addition to the written requirements listed above. These materials will be furnished at no cost to the Contractor.**

Any and all material furnished by the City to the Contractor **which is not used in this contract is the property of the City of Houston and shall be returned to the locations specified by the Traffic Signal Inspector before final payment is made to the contractor.**

2.04 PRODUCT DATA, SHOP DRAWINGS, AND SAMPLES

Contractor shall provide **three (3)** complete bound sets of Product Data, including: illustrations, standard schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate materials or equipment for all Contractor furnished equipment.

Contractor shall furnish shop drawings, as required in the standard specifications and standard details, or as required by the Engineer and/or the approved City of Houston

Representative. As a minimum, Contractor shall be required to furnish shop drawings for all structural elements, including cabinets, traffic signal poles, traffic signal arms, luminaires, luminaire supports, vehicular traffic signal head mounts, and pedestrian signal head mounts **prior** to ordering or fabricating these elements. Shop drawing submittals are required for each of the preceding elements. Contractor is not required to furnish shop drawings for any equipment furnished by the City of Houston.

Contractor shall furnish samples, or prototypes, of the following equipment within the specified time frame.

Item	Calendar Days from Bid Award
Controller Cabinet Assembly	45
Traffic Signal Controllers	60

PART 3 EXECUTION

3.01 OPERATION OF NEW & EXISTING TRAFFIC SIGNALS DURING CONTRACT PERIOD

To facilitate construction, the Contractor shall be required to install temporary poles, guys, cables, signals, conduits, wiring and adjustments as needed for temporary traffic signal operation during construction. **The Contractor will be responsible for furnishing and installing all materials as directed by the City of Houston Signal Inspector for temporary traffic signal installation.** The Contractor shall contact the signal inspector assigned to the project with a daily progress report. The Contractor shall

coordinate and obtain approval from the City of Houston signal inspector for all material as well as the configuration of the temporary traffic signal prior to installation. Proposed configurations and materials for the temporary traffic signal installation shall be submitted to the City of Houston Traffic Signal Engineering and Operations **no less than five (5) working days** prior to implementation. Operational timing and phasing of the temporary traffic signal installation during construction will be the responsibility of the City of Houston Traffic Management & Maintenance Branch personnel. Temporary traffic signal work will not be paid for directly, but shall be considered incidental to Traffic Control during construction. All temporary facilities shall be removed as directed by the signal inspector and remain the property of the Contractor upon operation of the new traffic signal construction.

The Contractor shall maintain existing signal installation(s) operation during construction of the new signal system. The Contractor may be required to photograph the existing signal to document existing status and functionality of all signal hardware and devices before beginning construction. It is the Contractor's responsibility to maintain all existing signal hardware and devices including signal heads and bulbs, interconnect, pedestrian elements, etc. The Contractor will not be responsible for power consumption of the signal during construction, and for work with the controller or inside the cabinet unless a city representative is onsite or as directed otherwise by the City of Houston. The Contractor shall submit all existing intersection documentation to the city inspector for the project before commencing work. The Contractor shall respond within **two (2) hours** after notification from appropriate City of Houston personnel. If the Contractor does not respond, the City of Houston will make necessary repairs and bill the contractor at an overtime rate (1.5X) for work performed.

The Contractor shall provide a minimum of five (5) working days notice to City of Houston representative at 713-881-3172 when seeking approval for a change in location, method of operation of traffic signals or traffic lanes, or change in traffic patterns or timing plans.

The Contractor shall provide a minimum of two (2) days notice when seeking approval regarding the replacement of an existing traffic signal installation.

The Signal Contractor shall be billed for any repair work performed on overtime (1.5X) for any repairs required because of Contractor negligence.

Uniformed Police Officers shall be employed by the contractor and are required to be on the job site. It shall be mandatory to have Uniformed Police Officer(s) for traffic signal turn-ons. Certified flagmen or Uniformed Police Officers may be used, as needed, for lane closures. It is the Contractor's responsibility to use the appropriate personnel for lane closures. The Texas Manual On Uniform Traffic Control Devices will be observed for all lane closures.

All work in this contract, requiring signal outages, or lane closures, shall be performed **between the hours of 9:00 A.M. and 4:00 P.M. Monday through Friday**, unless prior

authorization has been obtained from the Engineer and/or the approved City of Houston Representative.

Down time, if any, shall be kept to an absolute minimum. The switch over from the old system, or signal turn-on, shall be accomplished within the **six (6) hours between 9:00 A.M. and 3:00 P.M.** Contractor shall furnish and install all temporary traffic control (stop signs, flagmen, uniformed officers, etc.) during any down time, in addition to all required construction signs. Contractor shall inform the city of Houston to schedule a turn-on date **a minimum of 72 hours** in advance of need.

The Contractor shall hire a traffic engineer approved by the City of Houston to implement the traffic signal timings for the temporary signal system(s) and any modifications to the traffic control plan.

The Contractor shall furnish the City of Houston with a 24-hour telephone number for the purpose of forwarding malfunction calls. In the event that the Contractor cannot be reached at the above mentioned number, the City of Houston will take the necessary action to restore the traffic signal system to normal operation and all expenses incurred will be deducted from the final payment of the work order. All City of Houston labor expense shall be billed at overtime (1.5X) rates.

Contractor will be required to respond immediately and to initiate emergency maintenance operations on the jobsite a **maximum of four (4) hours** after the call is received from City of Houston. The Contractor shall pursue repairs to the traffic signal system and have it back in normal operation within a **maximum of six (6) hours** after call is received by the City of Houston, or a representative of the City of Houston.

3.02 CHARACTER OF WORKMEN AND EQUIPMENT

All equipment and workmen provided by the contractor for work hereunder shall be the best available for the kind of work being performed. Any person employed by the Contractor whom the City of Houston may deem temporarily or permanently incompetent or unfit to perform the work, shall under written instruction of the Engineer and/or the approved City of Houston Representative be removed from the job, and such person shall not again be employed on the work. Failure by the Contractor to provide adequate equipment may result in annulment of this contract as herein provided.

3.03 ELECTRICAL WORK

Electrical work is defined as installing cables, electrical terminations, and signal turn-ons. Installation of conduits is EXCLUDED from electrical work. Installation of loop wire in sawcut is EXCLUDED from electrical work.

All Contractor personnel working on City of Houston traffic signals performing duties directly involving setting up or installing signs, signals, pushbuttons, or traffic control shall be International Municipal Signal Association (IMSA) certified Level I, or greater. An IMSA certified Level II technician shall be present on site during all cabinet

terminations and during the installation of all signs, pavement markings, signals, pushbuttons, and traffic control.

3.04 SALVAGED MATERIALS

At existing traffic signal installations which are to be updated or modernized by the Contractor, all abandoned wire, cable, signals, poles, pole bases, pole tops, mast arms, signs and other miscellaneous equipment shall be taken down and/or removed. All equipment shall be reduced to simplest form. These salvaged materials are the property of the City of Houston and are to be delivered and unloaded to the location or locations designated by the City of Houston Traffic Signal Inspector assigned to the project.

3.05 ELECTRICAL SERVICE

The Contractor shall notify the City of Houston Traffic Signal Inspector assigned to the project **within seven (7) days of Contractor award** for power at intersection.

3.06 SUBCONTRACTING

If a vendor subcontracts any portion of a contract for any reason, they must include, in writing, the name and address of the subcontractor, name of the person to be contacted including telephone number and extent of work to be performed. This information is to be submitted with bid proposal. In the event of a change during construction, Contractor is required to submit new information to the Engineer and/or the approved City of Houston Representative, for approval, **five (5) days** prior to using the subcontractor on the job. City of Houston reserves the right to reject a bid of any bidder if the bid names a subcontractor who has previously failed in the proper performance of an award or failed to deliver on time contracts of a similar nature, or who is not in a position to perform properly under this award. City of Houston reserves the right to make determination as to the foregoing.

3.07 SYSTEM GROUNDING

All poles, cabinets, conduits, signal common, and service common shall be bonded with a No. 8 AWG bare copper wire, or equal, to form a continuous system and effectively grounded to 5/8-inch x 8 foot copperweld ground rods.

3.08 STRANDED GALVANIZED STEEL CABLE

Guy, messenger and catenary wires shall be Siemens Martin Grade, seven strand, galvanized, high strength steel cable, 5/16 inch diameter for guy and catenary wires and ¼ inch diameter for messenger wires.

3.9 POLE RAKING

Poles shall be set with a sufficient amount of rake so that they are plumb with the signal load or slightly raked away from the signal load. Cantilever pole structures and 4-1/2" OD steel poles should be plumb; strain poles should have a slight backward rake (1 to 2 inches); wood poles shall utilize down guys to maintain appropriate signal height clearance during construction. The Contractor shall rake the poles to the satisfaction of the Traffic Signal Inspector.

Rake is hereby defined as the inclination to the vertical measured at the top of the structure in the opposite direction of the strain axis.

3.10 ABANDONED FOUNDATIONS

The tops of unused foundations shall be removed to a depth of two feet (minimum) below grade and back-filled according to specifications.

3.11 LOADS AND STRESSES DUE TO CONSTRUCTION OPERATIONS

Contractor shall have full responsibility for preventing over-stresses of any structure, cables, poles or any part of them during construction. This also applies to existing work facilities affected by Contractor's operations. The Contractor shall fully check the effect of Contractor's operations in this regard and shall provide temporary supports and connections required to assure safety and stability of both new and existing work to prevent over-stress of any part thereof.

3.12 APPARATUS LOCATION

The locations of all poles, controllers, actuators and signals shown on the plans are diagrammatic only. The specific locations of such devices shall be decided by the appropriate design personnel and shall be staked out under their direction. Vehicular and pedestrian traffic signals shall be placed and aligned as the City of Houston Traffic Signal Inspector directs.

3.13 CONCRETE POUR

The time of day of the concrete pour shall be stipulated by the Contractor.

3.14 SEQUENCE OF WORK

Each new signalized intersection shall be in operable condition including electrical service within **fourteen (14) days** after the first signal pole is installed, unless conditions caused by a paving contractor or roadway construction contractor prevents the completion of the intersection(s).

The order in which the intersections are to be completed may be specified by the Engineer and/or the approved City of Houston Representative and it shall be the sole responsibility of the Contractor to schedule and coordinate their work. All work shall be coordinated in such a manner as to prevent delays resulting from work to be performed by others and to complete the Contractor's work within the specified time.

On the day when the intersection is to be turned on or its "Turn On" date, the Contractor will be given a "punch list" from the Signal Inspector for any items that need attention concerning the conditions of signal equipment. These items shall be completed within **ten (10) days** of the date on the "punch list" given to the contractor.

3.15 UTILITY COORDINATION

The Contractor shall contact the Lone Star Notification Center (713-223-4567, in Houston, 800-669-8344, outside Houston) **72 hours** before commencing any work to locate any utility lines in the construction area. It is the Contractor's responsibility to physically locate any water and sewer lines and to adjust the location of any foundation(s), for approval by the City of Houston Traffic Signal Engineering and Operations.

3.16 UNDERGROUND UTILITIES

The exact location of underground utilities and pipelines is not certain. The Contractor shall contact the Utility Coordinating Committee (U.C.C.) to determine exact locations of underground utilities prior to drilling for foundations or any other work that might interfere with or damage present facilities. Contractor shall be responsible for keeping the transmittal number from the U.C.C. current during construction.

3.17 LOCAL CONDITIONS

The Contractor shall make any additional investigations he deems necessary to properly bid any and all work related thereto. No additional compensation will be made available to the Contractor for work arising from failure to examine the site and/or subsoil conditions. Staking of specific locations by the Engineer and/or the approved City of Houston Representative shall not remove the Contractors responsibility for any damage caused by the Contractor to any underground utility.

3.18 RIGHTS OF VARIOUS INTERESTS

Wherever work being done by the City's forces or by any other Contractor is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by Engineer and/or the approved City of Houston Representative, to secure completion of the various portions of the work in general harmony.

3.19 TRENCHING

No trenching shall be allowed within five feet of a tree.

3.20 DIRECTIONAL DRILLING, BORE, AND JACK

No open cutting or trenching of streets, driveways and sidewalks shall be allowed without prior approval of the Engineer and/or the approved City of Houston Representative at each location. All conduit runs under streets, driveways or sidewalks shall be by directional drilling, bore, or jack. Water jetting methods shall not be accepted.

3.21 PUBLIC SAFETY AND CONVENIENCE

All work done under this contract shall be done in compliance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD). Each operation shall be considered a work zone area and shall be treated in accordance with the TMUTCD.

The Contractor shall have a Certified Worksite Traffic Supervisor who will be responsible for initiating, installing, and maintaining all traffic control devices as described in the TMUTCD. The Worksite Traffic Supervisor shall have at least one (1) year of experience directly related to worksite traffic control in a supervisory or responsible capacity and shall be certified by the American Traffic Safety Services Association or International Municipal Signal Association. The Worksite Traffic Supervisor will be incidental to Maintenance of Traffic and will not be measured separately for payment.

The Worksite Traffic Supervisor shall be available on a **twenty-four (24) hour day** basis and shall review the project on a day to day basis as well as being involved in all changes to traffic control. The Worksite Traffic Supervisor shall have access to all equipment and materials needed to maintain traffic control and handle traffic related situations. The Worksite Traffic Supervisor shall insure that routine deficiencies are corrected with a **twenty-four (24) hour** period.

The Worksite Traffic Supervisor shall be available on the site within **forty-five (45) minutes** after notification of an emergency situation, prepared to positively respond to repair the work zone traffic control or to provide alternate traffic arrangements.

Failure of the Worksite Traffic Supervisor to comply with these provisions may be grounds for decertification or removal from the project or both. Failure to maintain a designated Worksite Traffic Signal Supervisor or failure to comply with these provisions will result in temporary suspension of all activities except traffic and such other activities deemed to be necessary for project maintenance and safety.

The Contractor shall at all times so conduct their work as to insure the least possible obstruction to normal pedestrian and vehicular traffic including access to all public and private properties during all stages of construction, and inconvenience to the general public and the residents in the vicinity of the work, and to insure the protection of persons and property, in a manner satisfactory to the City Engineer and/or the approved City of Houston Representative.

The Contractor shall provide all barricades and take all necessary precautions to protect buildings and personnel. All work shall be complete in every respect and accomplished in a workmanlike manner and contractor shall provide for removal of all debris from City of Houston property.

The successful bidder shall at all times guard against damage or loss to the property of the City of Houston or of other vendors or contractors and shall be held responsible for replacing or repairing any such loss or damage. Any damage to landscaping in the work area, including sod shall be replaced at the Contractor's expense.

Prior to closing any section of the project to traffic, the Contractor shall furnish, erect and maintain barricades and warning signs at and in the vicinity of all construction projects at all times, both day and night, during the construction period of the contract, and all such barricades and warning signs, shall be in conformance with the requirements of Part 6 Temporary Traffic Control of the Texas Manual on Uniform Traffic Control Devices and as shown on the drawings.

Unless otherwise set forth in these specifications, the Contractor shall receive no direct compensation for furnishing, erecting, and maintaining the necessary barricades, lights, flares, signs, or for any other incidentals necessary for the good and proper safety, convenience, and direction of traffic during the period prior to final inspection and acceptance by the City of Houston.

3.22 SPECIAL REQUIREMENTS

A. A Steel Template shall be furnished by and used by the Contractor to secure anchor bolts while constructing pole foundations.

B. Pole Foundations shall be capped where needed, in order to provide a smooth, flat, and level surface. Capping shall consist of a one (1) inch thick mortar cap prepared with a 1:3 sand-cement mortar ratio. The cap shall be steel trowel finished.

C. Extra-length Concrete Pole Foundations shall be provided when required by site conditions. Reinforcing steel shall be increased by the same length as the increase in foundation length. Rods shown on Foundation Details shall be increased as follows: Each extra foot of foundation shall require on additional foot of length for hooked rods and two additional turns for helix.

D. All Special Foundations shall be designated and approved by the appropriate design engineer and/or the approved City of Houston Representative.

E. Sono Tube shall be used when the City of Houston Traffic Signal Inspector deems it necessary.

3.23 CONCRETE FINISHING

Honeycombed surfaces or other defects shall be patched with mortar of the same consistency as the mortar from which the concrete is made. Such mortar shall be well trowelled and then floated to remove trowel marks.

A. Finish for Formed Surfaces After patching above specified, exposed formed surfaces shall be finished by removing form marks, fins and other projections.

B. Finish for Uniformed Surfaces
   1. Patches in streets, driveways and walks shall be finished to match adjacent surfaces.
   2. Surfaces not Otherwise Specified – Steel trowel finish.

3.24 CONCRETE CURING

Immediately after placing or finishing, concrete surfaces shall be protected against moisture loss for **a minimum of seven (7) days**. Wet earth, waterproof paper, vinyl sheets or cotton mats shall be placed over concrete during curing period in order to insure fulfillment of this requirement. Membrane curing method may be used **EXCEPT when** concrete surfaces are to receive additional concrete or mortar, or are to be painted.

3.25 CONCRETE/PAVEMENT REPAIR

Repairs to concrete pavement shall be in accordance with Public Works Drawing Numbers 02902-01and 02902-02 titled, "Pavement Repair Details for Street Cuts",` and Specification Section 02951, "Pavement Repair and Resurfacing".

3.26 FLEXIBLE BASE PAVEMENT REPAIR

Repairs to flexible base pavement shall be made in accordance with Public Works Drawing Number 02902-01 titled, "Pavement Repair Details for Street Cuts", and Specification Section 02951, "Pavement Repair and Resurfacing".

3.27 TRAFFIC SIGNAL TESTING SERVICES

A. PROCEDURES

1. Selection:

   City of Houston shall employ an Independent Testing Laboratory to ensure Contract Document compliance.

2. Test Reports

   Testing laboratory will furnish reports to the Engineer, Structural Engineer, City of Houston and Contractor covering all of its determinations and all of its control

services. Reports will show all data customarily listed by the laboratory in reporting such tests including daily reports on quantities and types of materials together with location in the project. Form of reports will be as approved by the Engineer and/or the approved City of Houston Representative.

3. Test Methods

   Tests and inspections will be conducted in accordance with the requirements of these Specifications or, if not herein specified in accordance with the latest standards of the American Society for Testing and Materials or other recognized authorities.

4. Contractor's Responsibility

   (a) Cooperate with the testing laboratory and:

      (1) Make available, without cost, samples of all materials to be tested.

      (2) Furnish such normal labor as is necessary to obtain samples at the project and to assist in making slump tests and casting and curing cylinders.

      (3) Advise the laboratory of the identity of material sources and instruct these suppliers to allow inspections by the laboratory, and notify the laboratory sufficiently in advance of operations to allow for completion of initial tests and assignment of inspection personnel.

      (4) Contractor shall provide laboratory testing for each different concrete load.

   (b) Rejected Materials and/or Workmanship

      If, after initial tests have been performed, any materials and/or workmanship are rejected by the testing laboratory, Contractor shall
      (1) pay for any subsequent testing required for materials which have been rejected and/or replaced.

      Any materials and/or workmanship which are rejected by the testing laboratory by reason of failure to conform to the requirements of the Drawings and/or Specifications, shall be removed and replaced with new acceptable materials by the Contractor at the Contractor's own expense.

5. Additional Responsibility

   (a) The testing of all cable furnished shall be properly tested by the manufacturer and data submitted through the Contractor to the Engineer and/or the approved City of Houston Representative.

(b) All cable furnished to the job site shall be properly tested on the reel use.

3.28 PRELIMINARY WORK

A. PROCEDURES

1. City Requirements

(a) City requirements relating to the work of this section shall be ascertained by the Contractor. Contractor shall comply with all such requirements, including those relating to continued maintenance until completion of the project.

(1) If the City should require that certain portions of the work be performed by City personnel and equipment, all costs in connection therewith which are chargeable against the project shall be paid by the Contractor as an obligation of this Section

(2) If re-routing of vehicular and/or pedestrian traffic is necessary to complete work of this Contract, Contractor shall submit a copy of the Contractor's proposed re- routing plan to the City and the Engineer and/or the approved City of Houston Representative for approval **seventy-two (72) hours** before proceeding with the work.

(3) Re-installation and restoration of use of existing public and private installations, which are temporarily and/or permanently removed and/or relocated for work of this Contract, shall be performed as a part of the work of this Section

2. Existing Installations of City-Owned Property

(a) Perform all work relative to removal, storage and/or protection of existing installations of street lights and signs, fire hydrants, manholes, and other existing installations in the way of project construction.

(b) Provide and maintain approved temporary protection of existing installations until project completion and acceptance. Remove temporary protection when, and as, directed by the City.

(c) Existing facilities which are no longer required shall be disconnected as directed. Comply with the requirements of municipal agencies having jurisdiction over such work.

(d) Unless otherwise directed, all abandoned facilities shall be removed by Contractor and the holes and trenches filled with approved compacted fill.

3.29 GUARANTEES

All items installed under this specification, having a manufacturer's guarantee shall be installed by or under the direction of the manufacturer or the manufacturer's certified agent, when so required to conform with the manufacturer's guarantee, and all such manufacturer's guarantees, warranties and bonds shall be forwarded to the City of Houston representative.

The Contractor, by accepting this contract, guarantees all workmanship, materials and equipment performed or furnished and installed under this specification for a period of one year from date of completion and shall, at their entire expense and within said term of guarantee, repair, replace or adjust all faulty, broken, or maladjusted materials and/or equipment furnished and installed under this specification, including lamp replacement.

END OF SECTION

SECTION 02915

TREE PLANTING

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section specifies the requirements and standards for planting trees using a mechanical tree spade and container grown trees.

1.02 MEASUREMENT AND PAYMENT

A. Unit Price per tree.

1. Payment for tree planting is on unit price basis for each tree planted and shall include cost of watering during maintenance period for trees not served by irrigation system.

2. When shown on Drawings or directed by Project Manager to remove and relocate tree affected by trench zone, work shall be paid for under one of the following bid items.

a. Bid item "Remove and Relocate Tree" includes moving tree with truck mounted tree spade and replanting same tree in new location. Payment is for each tree removed and relocated.

b. Bid item "Remove, Temporary Store and Replant Tree" includes moving tree with truck mounted tree spade and replanting tree at temporary location, (determined by Contractor) maintaining tree until construction is complete and replanting same tree back to its original location. Payment is for each tree removed, stored and replanted.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. ANSI Z 60.1 - Nursery Stock.

1.04 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330-Submittal Procedures.

B. Submit physical address for location of trees. Trees shall be tagged in field for transplanted trees, and at the nursery for container trees, for inspection by City Engineer or City Forester. Tag shall be securely attached to branch, shall be waterproof, and shall legibly bear designation of botanical and common name. Submit right of entry agreement for City Engineer or City Forester to access tree farm or nursery in order to inspect trees.

C. Submit following documentation for Compost to be utilized:

1. Feedstock by percentage in the final compost.

2. Documentation that the compost meets federal and state health and safety regulations.

3. Documentation that the composting process has met time and temperature requirements.

4. Copy of producer's STA certification.

5. Copy of the current TCEQ compliance statement signed by facility manager for any biosolids compost utilized.

1.05 QUALITY ASSURANCE

A. Transplanted trees shall be planted by a contractor specializing in tree spade planted trees. The contractor shall have a minimum of 8 years experience in planting trees with truck mounted tree spades. The contractor shall have immediate access to required trees in a tree farm/field located within 40 miles of project site. Container trees shall be planted by Landscaping firm with a minimum of 3 years experience in planting container grown trees.

B. Substitutions of specified tree species and sizes, and tree spade and container size shall not be made without written approval from City Engineer. When specified planting material is not obtainable, submit proof on non-availability together with proposal for use of equivalent material. Substitutions of larger size than specified will be allowed, provided it meets requirements article 2.01 of this section, but shall be provided at no additional cost to owner.

1.06 WARRANTY

A. Contractor shall warrant trees against defects including death, unsatisfactory growth, or loss of shape due to improper pruning, maintenance, or lack of moisture, for 2 year after completion of construction (substantial completion). Contractor shall plumb leaning trees during warranty period.

B. Remove and replace trees found to be dead during warranty period. Remove and replace trees which have more than 40% twig and/or foliage dieback or are in doubtful condition at the end of warranty period, or if approved by City Engineer, extend warranty period for such trees for a full growing season. Any trees that are required to be replaced under warranty shall be replaced at no addition cost to owner.

PART 2 PRODUCTS

2.01 TREES

C. Provide trees which are straight and symmetrical and have persistently preferred main leader. Co-dominant or dual leaders will not be allowed or accepted. Trees with a significant number of v-crotches, or trees with major branches that have v-crotches will not be allowed or accepted. The crown shall be in good overall proportion to the entire height of the tree. The minimum crown spread and height shall conform to the following standards for each tree:

1. Transplant Trees:

   a. 3” diameter tree shall have a minimum canopy spread of 50” diameter, total tree height of 8 feet, and canopy height of 5 feet.

   b. 4” diameter tree shall have a minimum canopy spread of 70” diameter, overall tree height of 10 feet, and a canopy height of 6.5 feet.

   c. 5” diameter tree shall have a minimum canopy spread of 90” diameter, overall tree height of 12 feet, and a canopy height of 8 feet.

   d. 7” diameter tree shall have a minimum canopy spread of 110” diameter, overall tree height of 15 feet, and a canopy height of 10 feet.

2. Container Trees:

   a. Tree diameter, overall tree height, and canopy height shall conform to ANSI Z 60.1 (most current publication).

B. Tree diameter and/or container/spade size shall be as specified on the drawings. Tree diameter to be measured 6 inches above natural grade or planting media for each tree.

C. Trees shall be healthy, vigorous, and in overall good condition. Trees shall be free of disease, insects, eggs, larvae; and free of defects such as wasp galls, knots, trunk wounds or scars, abrasions or disfigurement.

D. Foliage shall be dark green, as dark as is typical for the given species. The tree foliage shall not be chlorotic, necrotic, or dying back.

2.02 SOIL CONDITIONER OR ROOT STIMULATOR

A. Root stimulator shall contain at a minimum the following ingredients: Ectomycorrhizal Fungi, VA Mycorrhizal(VAM) Fungi, Rhizosphere Bacillus spp., Kelp Meal, Humic Acid, and Soluble Yucca.

2.03 SAND BACKFILL

A. Sand backfill shall be a fine sandy loam, typical of the soil at the project site, or fine bank sand. The back fill shall be free of noxious weeds, grasses, sticks, roots or stone and shall be consistent in texture.

2.04 COMPOST

A. Compost shall have been produced by aerobic (biological) decomposition of organic matter. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food-processing residuals, manure or other agricultural residuals, forest residues, bark, and paper. Compost and wood chips shall not contain any visible refuse, other physical contaminants, or any substance considered harmful to plant growth. Compost shall not contain materials that have been treated with chemical preservatives as a compost feedstock or as a wood chip. Compost shall not contain mixed municipal solid waste compost. Compost shall meet all applicable 40 CFR 503 standards for Class A biosolids and TCEQ health and safety regulations as defined in the TAC, Chapter 332, including the time and temperature standards in Subchapter B, Part 23. Meet the requirements of the United States Composting Council (USCC) Seal of Testing Assurance (STA) program.

2.05 MULCH

A. Mulch shall be shredded hardwood, free of noxious weed seeds.

2.06 WATER

A. Water shall be potable from municipal water supplies.

2.07 SOURCE QUALITY CONTROL

A. Notify City Engineer, prior to delivery and planting, with location where trees that have been tagged for planting may be inspected. Trees will be inspected for compliance with this specification.

PART 3 EXECUTION

3.01 EQUIPMENT (Applies to Transplant Trees)

A. Tree spade shall be in good condition with minimum tolerances between digging blades. All blades shall be true to their designed spade free of bends and deformities. The tree spade shall be mounted on suitable, stable machines capable of supporting the weight of all dug materials and heavy enough to force all blades into the soil to full depth. Holes to receive machine transplanted trees shall be dug with machines of like size and manufacture to that which is used to dig the intended tree.

B. Trees shall be transplanted with minimum tree spade sizes for maximum tree diameter per the following standards:

1. Maximum tree diameter for 50” tree spade shall be 3”

2. Maximum tree diameter for 60” tree spade shall be 4”

3. Maximum tree diameter for 80” tree spade shall be 5”

4. Maximum tree diameter for 90” tree spade shall be 7”

5. Maximum tree diameter for 120” tree spade shall be 9”

3.02 PREPARATION FOR PLANTING

A. Schedule work so that planting can proceed as rapidly as the planting site becomes available. Plant trees after final grades are established and prior to planting of turf, unless otherwise approved by City Engineer in writing. If planting of trees occurs after seeding work, protect turf areas and promptly repair damage to turf resulting from tree planting operations.

B. Layout individual trees at locations shown on Drawings. In case of conflicts, notify City Engineer before proceeding with work. Trees shall be laid out and approved by City Engineer and City Forester prior to planting.

C. The contractor shall be responsible for locating and confirming underground utilities.

D. Trees shall be pruned, at the farm, to remove dead, diseased, dying, or broken branches

that will be detrimental to the future shape or structure of the tree. Old pruning stubs should also be removed. All pruning cuts should be made sufficiently close to the branch collar, so as not to leave a protruding stub, without cutting into the branch collar. Each cut shall be made with the appropriately sized pruning shear, which should have properly matched, sharpened blades. Pruning cuts shall not be painted or otherwise treated.

E. Trees are subject to inspection at the tree farm or location of collection. When directed, provide and use serialized locking tags on trees.

F. Contractor shall notify City Engineer and City Forester at least 48 hours before delivering trees to worksite. Coordinate with City for inspection and approval of materials upon delivery. Remove rejected trees from the worksite and replace as directed.

G. Container grown trees shall be thoroughly watered prior to leaving tree farm or nursery.

3.03 COLLECTING, TRANSPORTING AND PLANTING

Transplant Trees

A. Tree shall be centered in tree spade at digging.

B. No damage to branches or trunk shall be allowed while backing onto tree at tree farm, digging tree, or pulling away from tree after planting. Damage to tree trunk caused by the digging or planting of the tree, will be grounds for non-acceptance of tree under this specification.

C. Roots protruding from the digging blades shall be pruned flush with the root ball prior to planting.

D. Contractor shall ensure tree is tied down so that the total height of the tree spade and tree do not exceed legal height limits.

E. Tree shall be covered with an open-weave fabric tarp to minimize wind damage and desiccation of leaves during transportation from collection site to planting site.

F. Each tree shall be planted in its final planting site within 4 hours of being dug from the collection site.

G. Tree shall be planted plumb and the root ball shall be set 2-3 inches above the finished grade.

H. No staking or guying of the tree should be installed.

I. Voids between existing grade and tree root ball shall be backfilled with sand backfill. The sand backfill should be thoroughly watered into the voids, so that no air packets remain.

J. A water holding basin shall be constructed around each tree. The basin should be constructed with the sand backfill and shall be constructed directly over the void between the existing grade and root ball, 6-8" in height, and 8-10" in width. The top of the root ball shall not be covered with sand backfilled or any other type of soil.

K. Prior to mulching, each tree shall be thoroughly watered 2 separate times. Each time the watering basin should be filled with water and the water allowed to soak the tree and force sand backfill into all voids. After the second watering basin should be rebuilt to its original shape.

L. Each tree shall be thoroughly soaked with root stimulator, per label instructions.

M. Mulching shall be completed within 24 hours of planting. A 4" deep layer of mulch shall be applied to the entire water holding basin and top of root ball. No much shall be applied directly against the trunk of the tree.

N. Control dust caused by planting operations. Dampen surfaces as required. Comply with pollution control regulations of governing authorities.

Container Trees

A. Excavate planting pit to a depth equal to planting media height in container, or 1-2" shallower. Do not over excavate, to ensure planted root ball rest on undisturbed sound soil. Planting pit shall have a diameter that is at least 2 feet wider than diameter of root ball.

B. When conditions detrimental to plant growth are encountered, such as unsatisfactory soil, obstructions, or adverse drainage conditions, notify City Engineer and/or City Forester.

C. Edges of planting pit shall be scarified with gouges a minimum of 1" deep and 1" wide spaced no wider than 8" on center.

D. Trees shall be planted within 24 hours of excavating planting pits to minimize soil desiccation.

E. Trees shall be handled by container during transportation and planting. Trees shall not be handled by grasping trunk only.

F. Trees shall be covered with open weave tarp in transportation from nursery to planting site, to minimize tree and leaf desiccation.

G. Deliver trees after preparations for planting have been completed and plant immediately. If planting does not occur within 6 hours of delivery, set trees in shade, protest from weather and mechanical damage, and keep root balls moist by covering with mulch, compost, burlap, or other acceptable means of retaining moisture. Water trees as needed

to avoid root ball desiccation.

H. Each tree shall be removed from container without cracking or disturbing root ball. The circumference of the root ball shall be scored with sharp utility knife ½" deep, from top to bottom of ball, at 8" intervals to cut any circling roots.

I. Set root ball in planting pit, on undisturbed soil, in center of pit and plumb plant. Top of root ball shall be at same elevation of finished grade or 1-2" above finished grade.

J. Backfill planting pit around root ball in lifts, each lift shall be 1/3 the depth of the root ball. Pit shall be thoroughly watered after each lift to remove air pockets. Backfill shall consist of the following materials:

1. Soil excavated from planting pit: 75 percent

2. Compost: 15 percent

3. Peat moss: 10 percent

K. Construct a plant basin at least 6 inches deep with an inside diameter equal to the planting pit diameter and with a level top around the plant unless otherwise indicated on plans. Use excavated soil from the planting pit, amended backfill material, or approved material for the basin.

L. Mulching shall be completed within 24 hours of planting. A 4" deep layer of mulch shall be applied to entire water holding basin and top of root ball. No mulch shall be applied directly against the trunk of the tree.

M. Each tree shall be guyed and staked immediately after planting. Each tree shall have a minimum of 2 post; more may be required depending on soil structure. Provide adequate number of post to ensure tree stability during establishment. Tree shall be secured by plastic tree chain, do not use wire with plastic or rubber guards.

N. Control dust caused by planting operations. Dampen surfaces as required. Comply with pollution control regulations of governing authorities.

3.02 FIELD QUALITY CONTROL

A. City Engineer may reject unsatisfactory or defective material at anytime during progress of work. Contractor shall remove rejected trees immediately from site and replace with specified materials. Plant material not installed in accordance with these specifications will be rejected.

B. An inspection to determine final acceptance will be conducted by City Engineer and City Forester at the end of the 24 month maintenance period. Additional inspections will be conducted for extended warranty periods provided for in paragraph 1.06B.

3.03 MAINTENANCE PERIOD

A. Contractor shall maintain trees during planting operations and for a period of 24 months after completion of construction (substantial completion).

B. Contractor shall water trees during maintenance period to ensure tree establishment. Trees served with bubblers or drip irrigation will not require manual watering.

C. Contractor shall apply a minimum of 25 gallons of water to each tree weekly, or more if required to maintain healthy vigorous growth. No watering shall be required during weeks when the planting site receives at least 1” of rainfall. Rainfall to be measured at planting site.

3.04 CLEANUP AND PROTECTION

A. During planting work, keep pavement clean and work area in an orderly condition.

B. No open planting holes shall be left at planting site without immediate supervision by planting personnel. Use plywood, or other suitable material, to cover open hole when not under immediate supervision.

C. Protest planting work and material from damage due to planting operations. Maintain protection during installation and maintenance period. Treat, repair, or replace damaged planting work as directed by City Engineer.

D. Dispose of excess soil and waste in accordance with requirements of Section 01576-Waste Material Disposal. On-site burning of combustible materials will not be permitted.

END OF SECTION

SECTION 02921

HYDRO MULCH SEEDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Seeding, fertilizing, mulching, and maintenance of areas indicated on Drawings.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for hydro mulch seeding is on an acre basis, within limits of construction if shown on the drawings.

2. No payment will be made for hydro mulch seeding under this Section if limits of constructions are not shown on the drawings. Include payment in Section 01740 – Site Restoration.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification from supplier that each type of seed conforms to these specifications and requirements of Texas Seed Law. Certification shall accompany seed delivery.

C. Submit certificate stating that fertilizer complies with these specifications and requirements of Texas Fertilizer Law.

PART 2 PRODUCTS

2.01 MATERIALS

A. Topsoil: Conform to material requirements of Section 02911 - Topsoil.

B. Seed: Conform to U.S. Department of Agriculture rules and regulations of Federal Seed Act and Texas Seed Law. Seed shall be certified 90 percent pure and furnish 80 percent germination and meet following requirements:

1. Rye: Fresh, clean, Italian rye grass seed (lollium multi-florum), mixed in labeled proportions. As tested, minimum percentages of impurities and germination must be labeled. Deliver in original unopened containers.

2. Bermuda: Extra-fancy, treated, lawn type common bermuda (Cynodon dactylon). Deliver in original, unopened container showing weight, analysis, name of vendor, and germination test results.

3. Wet, moldy, or otherwise damaged seed will not be accepted.

4. Seed requirements, application rates, and planting dates are:

TYPE	APPLICATION RATE POUNDS/A	PLANTING DATE
Hulled Common Bermuda Grass 98/88 Unhulled Common Bermuda Grass 98/88	40 40	Jan 1 to Mar 31
Hulled Common Bermuda Grass 98/88	40	Apr 1 to Sep 30
Hulled Common Bermuda Grass 98/88 Unhulled Common Bermuda Grass 98/88 Annual Rye Grass (Gulf)	40 40 30	Oct 1 to Dec 31

C. Fertilizer: Dry and free flowing, inorganic, water soluble commercial fertilizer, which is uniform in composition. Deliver in unopened containers which bear manufacturers guaranteed analysis. Caked, damaged, or otherwise unsuitable fertilizer will not be accepted. Fertilizer shall contain minimum percentages of following elements:

1. Nitrogen: 10 Percent

2. Phosphoric Acid: 20 Percent

3. Potash: 10 Percent

D. Mulch:

1. Virgin wood cellulose fibers from whole wood chips having minimum of 20 percent fibers 0.42 inches in length and 0.01 inches in diameter.

2. Cellulose fibers manufactured from recycled newspaper and meeting same fiber content and size as for cellulose fibers from wood chips.

3. Dye mulch green for coverage verification purposes.

E. Soil Stabilizer: "Terra Tack 1" or approved equal.

F. Weed control agent: Pre-emergent herbicide for grass areas, such as "Benefin," or approved equal.

PART 3 EXECUTION

3.01 PREPARATION

A. Place and compact topsoil in accordance with requirements of Section 02911 - Topsoil.

B. Dispose of Objectionable and Waste Materials in accordance with Section 01576 - Waste Material Disposal.

3.02 APPLICATION

A. Seed: Apply uniformly at rates given in Paragraph 2.01 B for type of seed and planting date.

B. Fertilizer: Apply uniformly at rate of 500 pounds per acre.

C. Mulch: Apply uniformly at rate of 50 pounds per 1000 square feet.

D. Soil Stabilizer: Apply uniformly at rate of 40 pounds per acre.

E. Weed Control Agent: Apply at manufacturer's recommended rate prior to hydro mulching.

F. Sod: Lay single row of sod along perimeter where top soil and pavement intersect. Apply in conformance to Section 02922 - Sodding.

G. Suspend operations under conditions of drought, excessive moisture, high winds, or extreme or prolonged cold. Obtain Project Manager approval before resuming operations.

3.03 MAINTENANCE

A. Maintain grassed areas minimum of 90 days, or as required to establish an acceptable lawn. For areas seeded in fall, continue maintenance following spring until acceptable lawn is established.

B. Maintain grassed areas by watering, fertilizing, weeding, and trimming.

C. Repair areas damaged by erosion by regrading, rolling and replanting.

D. Reseed small, sparse grass areas. When sparse areas exceed 20 percent of planted area, reseed by hydro mulch.

E. Mow grass when height reaches 3 1/2 inches or greater on average before final acceptance. Mow to height of 2 1/2 inches.

END OF SECTION

SECTION 02922

SODDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Restoration of existing lawn areas disturbed by construction shall be by installation of new sod.

B. Planting of sod within areas designated on Drawings for purpose of surface stabilization, channel stabilization or vegetation buffer strips.

C. Sod is defined as blocks, squares, strips of turfgrass, and adhering soil used for vegetative planting. To be placed edge to edge for complete coverage.

D. Lawn is defined as ground covered with fine textured grass kept neatly mowed.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for sodding is on square yard basis.

2. For utility construction, no separate payment will be made for sodding. Include payment in Section 01740 under site restoration.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

1.04 QUALITY ASSURANCE

A. Sod only when weather and soil conditions are deemed by Project Manager to be suitable for proper placement.

B. Water and fertilize new sod.

C. Guarantee sod to be growing 30 days after substantial completion.

D. Maintenance Period:

1. Begin maintenance immediately after each section of grass sod is installed and continue for 30 day period from date of substantial completion.

2. Resod unacceptable areas.

3. Water, fertilize, control disease and insect pests, mow, edge, replace unacceptable materials, and perform other procedures consistent with good horticultural practice to ensure normal, vigorous and healthy growth. Install disease control within guidelines set forth by Structural Pest Control Board of the State of Texas.

E. Notify Project Manager 10 days before end of maintenance period for inspection.

PART 2 PRODUCTS

2.01 SOD

A. Species: Bermuda (Cynodon Dactylon), Buffalo (Buchloe Dactyloides), or St. Augustine (Stenotaphrum Secundatum) Gulf Coast variety to match existing sod.

B. Contents: 95 percent permanent grass suitable to climate in which it is to be placed; not more than 5 percent weeds and undesirable grasses; good texture, free from obnoxious grasses, roots, stones and foreign materials.

C. Size: 12 inch wide strips, uniformly 2 inches thick with clean-cut edges.

D. Sod is to be supplied and maintained in healthy condition as evidenced by grass being normal green color.

2.02 FERTILIZER

A. Available nutrient percentage by weight: 12 percent nitrogen, 4 percent phosphoric acid, and 8 percent potash; or 15 percent nitrogen, 5 percent phosphoric acid, and 10 percent potash.

2.03 WEED AND INSECT TREATMENT

A. Provide acceptable treatment to protect sod from weed and insect infestation. Submit treatment method to Project Manager for approval. Install insect and disease control within guidelines set forth by Structural Pest Control Board of the State of Texas.

2.04 WATER

A. Potable, available on-site through Contractor's water trucks. Contractor may use City of Houston hydrants when water use is measured through Contractor's meter. Do not use private resident's water.

2.05 BANK SAND

A. Free of clay lumps, roots, grass, salt or other foreign material.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that soil placement and compaction have been satisfactorily completed. Verify that soil is within allowable range of moisture content.

B. Top soil shall be free of weeds and foreign material immediately before sodding.

C. Do not start work until conditions are satisfactory. Do not start work during inclement or impending inclement weather.

D. Rake areas to be sodded smooth, free from unsightly variations, bumps, ridges or depressions.

E. Spread 2 inch layer of bank sand over areas to be sodded prior to planting of sod.

F. Apply fertilizer at rate of 25 pounds per 1000 square feet. Apply after raking soil surface and not more than 48 hours prior to laying sod. Mix thoroughly into upper 2 inches of soil. Lightly water to aid in dissipation of fertilizer.

3.02 APPLICATION

A. Full Sodding: Lay sod with closely fitted joints leaving no voids and with ends of sod strips staggered. Lay sod within 24 hours of harvesting.

B. On slopes 2:1 and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. Drive pegs flush with soil portion of sod.

C. Prior to placing sod, on slopes 3:1 or where indicated, place Hold/Gro or Roll Lite or equal over topsoil. Securely anchor in place with posts sunk firmly into ground at maximum 16 feet on center along pitch of slope and equal to width of wire mesh horizontally across slopes.

D. After sod is laid, irrigate thoroughly to secure 6-inch minimum penetration into soil below sod.

E. Tamp and roll sod with approved equipment to eliminate minor irregularities and to form close contact with soil bed immediately after planting and watering. Submit type of tamping and rolling equipment to be used to Project Manager for approval, prior to construction.

3.03 MAINTENANCE

A. Watering:

1. Water lawn areas once a day with minimum 1/2 inch water for first 3 weeks after area is sodded.

2. After 3 week period, water twice a week with 3/4 inch of water each time unless comparable amount has been provided by rain.

3. Make weekly inspections to determine moisture content of soil unless soil is in frozen condition.

4. Water in afternoon or at night to enable soil to absorb maximum amount of water with minimum evaporation.

B. Mowing:

1. Mow sod at intervals which will keep grass height from exceeding 3 1/2 inches.

2. Set mower blades at 2 1/2 inches.

3. Do not remove more than one-half of grass leaf surface.

4. Mow sodded areas requiring mowing within 1 month after installation with light-weight rotary type mower. Mow sod only when dry and not in saturated or soft condition.

5. Remove grass clippings during or immediately after mowing.

C. Fertilizer and Pest Control:

1. Evenly spread fertilizer composite at rate of 40 pounds per 5000 square feet or as recommended by manufacturer. Do not place fertilizer until 2 weeks after placement of sod.

2. Restore bare or thin areas by topdressing with mix of 50 percent sharp sand and 50 percent sphagnum peat moss.

3. Apply mixture 1/4 to 1/2 inch thick.

4. Treat areas of heavy weed and insect infestation as recommended by treatment manufacturer.

D. Restrict all traffic from sodded areas until sod is established or for minimum 10 days during growing season. Use wood lath and plastic tape to cordon sodded areas. Maintain tape and lath throughout for minimum 30 days during growing season.

3.04 CLEANUP

A. During course of planting, remove excess and waste materials; keep lawn areas clean and take precautions to avoid damage to existing structures, plants, grass, and streets.

B. Remove barriers, signs, and other Contractor material and equipment from project site at termination of establishment period.

C. Dispose of unused materials and rubbish in accordance with Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 16710

PULL BOXES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pull boxes of the various types and sizes required complete with lids.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for this item will be measured as each ground box and or extension by type, complete in place. Concrete aprons, if required, will be measured as each pull box with concrete apron, complete, in place.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Pull Boxes" of the various types and sizes specified. The price shall be full compensation for excavating and backfilling; for constructing, furnishing and installing the pull boxes and concrete rings when required; for concrete and reinforcing steel; and for all labor, tools, equipment and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new materials that comply with the details shown on the plans and the requirements of this specification.

B. All pull boxes shall be constructed of polymer concrete consisting of sand and aggregate bound together with a polymer resin. Internal reinforcement may be provided by means of steel, fiberglass, or a combination of both. Chopped fiberglass, polyethylene, or polystyrene are not allowed for internal reinforcement.

C. The material used to shall have the following minimum allowable properties:
Compressive Strength: 10,000 psi
Flexural Strength: 7,000 psi
Tensile Strength: 1,500 psi

PART 3 EXECUTION

3.01 INSTALLATION

A. General

1. Installations shall be in commercial and residential sidewalks and behind curbs where no deliberate traffic is planned.

2. Pull boxes and extensions shall be furnished in the following nominal sizes (Width X Length X Depth):

Type	Purpose	Dimensions
A	Detector Loops & Hardwire Interconnect	13” x 18” x 24”
B	Standard traffic signal pull box, but also used for detector loops where multiple loops enter the pull box	17” x 30” x 24” 17” x 30” x 12” (Extension)
C	Standard pull box used for most communications applications, or where a larger pull box is needed due to multiple conduits	26” x 38” x 24” 26” x 38” x 12 (Extension)

3. Each enclosure shall be designed and constructed flush to grade with the cover fitting flush to the box.

4. Each enclosure shall be suitable for installation in either direct or buried native soil, embedded in concrete or embedded in asphalt surfacing. A concrete collar shall be furnished for each installation in asphalt, or where called for on the plans.

5. All enclosures shall withstand shipping and installation practices without chipping, cracking, or structural damage. Any pull box damaged, or cracked, during installation shall be replaced by the Contractor.

6. All pull box covers shall be equipped with a minimum of two stainless steel lockdown mechanisms. Multiple piece covers shall be equipped with a means of interlocking with each other, or each section shall be secured with two stainless steel lockdown mechanisms. Tools to unlock the covers shall be furnished. A minimum of one (1) tool shall be furnished with each ten (10) pull boxes supplied. All covers shall have a logo recessed into the cover with the legend, “TRAFFIC SIGNAL” in two-inch minimum height letters, or other as specified by the City of Houston.

7. All covers shall have a recessed access point to allow removal of the cover with a special lifting tool. One lifting tool shall be furnished with each ten (10) pull boxes. The access

point shall be located and designed to allow the maximum amount of leverage and safety possible.

8. Pull boxes shall be designed and suitable for installation and use through a temperature range of –40 degrees C to 60 degrees C.

9. Material Safety Data Sheets (MSDS) must be attached in a weather tight vessel on each order.

10. A certified copy of all test reports shall be signed and sealed by a registered State of Texas Professional Engineer and submitted prior to receipt of shipment.

11. All pull boxes and covers shall be rated for a static vertical design load of 15,000 pounds, minimum. All pull boxes must pass a minimum static vertical load test of at least 22,500 pounds. A physical description of the testing methods shall be included with the test reports. Load versus deflection curves shall be provided.

12. All pull boxes shall be capable of supporting a lateral load, design bearing pressure, of 600 pounds per square foot. Lateral load testing shall be applied to the longest dimension. The load shall be transmitted by a flat, rigid plate 24 inches wide by the depth dimension of the enclosure, bearing against any suitable medium which will conform to the shape and angle of the enclosure sidewall to achieve uniform loading.

13. Pull box Vertical Load Testing: The 15,000 pounds design load and 22,500 pounds testing load shall be distributed over a 5 inch by 10 inch area. All covers shall be tested, installed on a typical pull box. The loading pad shall be centered on the part of the cover that will produce the maximum deflection under load. A deflection-measuring device shall be used to measure deflection. Deflection under design load shall not exceed:

Cover	½ inch
Pull box	¼ inch per foot of pull box length.

14. Permanent deflection of the cover or pull box shall not interfere with the placement or removal of the cover.

15. All covers shall be skid resistant and should have a minimum coefficient of friction of 0.50 on the top surface of the cover.

16. Any point on the cover must be able to withstand a 70 foot-pound impact with a 12-pound weight having a “C” Tup (ASTM D-2444) without puncturing or splitting.

17. Installation of the pull boxes shall be in conformance with the details shown on the plans. When shown on the plans, a concrete ring or apron shall be provided.

3.02 CONDUIT ENTRANCE TO PULL BOX

A. Hydraulic conduit entrance punchout tools or equivalent shall be used to provide necessary entrances to pull boxes leaving a clean surface area for the insertion of conduit.

END OF SECTION

SECTION 16711

TRAFFIC SIGNAL CONDUIT

PART 1 GENERAL

1.01 SECTION INCLUDES

All traffic signal conduit installed above ground shall be rigid steel, hot-dipped, galvanized conduit. Underground conduit installed in unpaved areas may be either rigid steel, hot-dipped galvanized conduit or Schedule 80 polyvinyl chloride (PVC) conduit, unless specified on the plans. Underground conduit installed under paved roadways and shoulders shall be rigid steel, hot-dipped galvanized conduit.

Unless otherwise shown on the drawings, all conductors shall be in conduit except when in metal poles. All conduits and fittings shall be of the sizes and types shown on the drawings. Each section of conduit shall bear evidence of approval of Underwriter's Laboratories.

The Contractor may, at the Contractor's own expense, use conduit of larger size than specified on the drawings providing that the larger size is used for the entire length of the conduit run.

1.02 UNIT PRICES

A. Measurement

This Item will be measured by the linear foot of the various sizes and types of conduit installed based on the type of surface as indicated in the bid item. Conduit shall be measured horizontally along the surface from center of pullbox to center of pullbar or foundation. Risers shall be measured as the amount of conduit extending from the ground surface.

B. Payment

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Conduit" of the various types and sizes specified. The price shall be full compensation for furnishing and installing conduit; for directional drilling, boring, excavating, furnishing and placing backfill, replacing pavement structure, sod, riprap, curbs or other surfaces; for marking location of conduit (when required); for furnishing and installing all fittings, junction boxes, special radius sweeps, and expansion joints, conduit straps; and for all labor, tools, equipment and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Electrical PVC Conduit - The use of Electrical PVC conduit will be allowed as long as all guidelines set forth in the NEC (National Electrical Code) book are followed. Schedule 80 Electrical PVC will only be used in pertinent applications. In locations above the ground, rigid metal conduit will be used. All grounding procedures set forth in the NEC shall be followed.

PVC conduit shall be joined by solvent-weld method in accordance with the conduit manufacturers recommendation. No reducer couplings shall be used unless specifically indicated on the drawings.

B. Rigid Steel, Hot-Dipped, Galvanized Conduit

1. All conduit shall be of mild steel piping, galvanized inside and outside, and shall conform in all respects to the Federal Specification WW-C-581c, American Standard Rigid Steel Conduit Specification C80.1, latest revision, and Underwriters' Laboratories Specifications.

2. Trade Names - Conduit manufactured by Clifton, Pittsburg-Standard, Triangle or Youngstown conforms to the provisions of this specification. Other brands of rigid steel, hot dipped, galvanized electrical conduit may be approved by the engineer provided samples and engineering data submitted by the bidderequal the provisions of this specification.

3. Protective Coating - The galvanized coat of zinc shall be of uniform thickness, not less than 0.0008 inch, applied by the hot-dipped process to not only the inside and outside surfaces of the conduit, but also to the threads of the conduit.

4. Threading and Reaming - Each piece of conduit shall be straight, free from blisters and other defects, cut square and taper reamed, and furnished with coupling in 10 ft. lengths threaded each end. The interior threaded surface of each coupling shall be galvanized to insure 100% galvanic protection when coupled together with lengths of hot-dipped rigid conduit with hot-dipped galvanized threads.

5. Rigid Elbows - Rigid standard and special radius elbows shall be made from the same grade of mild steel piping as rigid steel conduit. They shall be galvanized so that not only the exterior and interior surfaces shall have a galvanized coating but also the threaded area, thereby insuring 100% galvanic protection on all surfaces.

6. Chemical Test for Coating - The hot galvanized coating shall be of such quality and uniformity that a sample of hot-galvanized conduit will not show a fixed deposit of copper after four (4) immersions or dips in a standard copper sulfate solution.

7. Bending Test - The hot-galvanized coating on the inside and outside surfaces shall be sufficiently elastic to prevent cracking or flaking when a sample of finished conduit is bent 90 degrees, at a minimum bend of 60 degrees inner edge of the bend of six (6) times the inside diameter of the conduit. For conduits two (2) inches in diameter, or smaller, special eighteen (18) inch minimum radius sweeps shall be furnished and installed by the contractor.

PART 3 EXECUTION

3.01 CONSTRUCTION METHODS

A. General - The contractor shall familiarize himself with the provisions of the General and Special Conditions in regard to permits, codes, laws and ordinances, and these provisions shall be controlling factors, except as specifically noted otherwise or supplemented herein.

All work shall be done in accordance with the latest rules and regulations of the National Board of Fire Underwriters, the National Electrical Safety Code and all local ordinances.

B. Coordination - The work shall be carefully coordinated with work of other trades. Wherever work covered under this item, the order of work shall be carefully scheduled and coordinated to secure the completion of the various portions in the best possible manner. The rights of the various interests and the sequence when in dispute, shall be established by the Engineer and the Engineer's instructions as to priority and scheduling shall be final and binding.

C. Placement - All joints in conduit shall be cut square, reamed smooth and drawn up tight. Concealed conduit shall run in as direct a manner as practicable, with maximum radius bends. All bends shall be free from dents or flattening. Not more than the equivalent of three quarter bends (two hundred seventy degrees) shall be used in any run between terminals, outlets and junction or pull boxes. Conduit joints shall be made with approved couplings and unions; where conduit cross expansion joints, expansion fittings shall be installed. Conduit runs underground shall be installed a minimum of 24 inches below finished grade, except where it is impossible or impractical. The Engineer or approved designer shall be the sole judge of the permissible depth of conduit installation. The conduit shall be installed as shown on the plans or as directed by the Engineer. Each conduit run shall be swabbed after installation, and a No. 9 galvanized steel pull wire shall be inserted in each conduit and folded in a manner making it easy to retrieve from each end. The conduit ends shall be capped or plugged until cabling and wiring operations commence.

Upon request of the Engineer, the contractor shall draw a full-time metal brush, attached by swivel joint to a pull tape through "metal conduit" and a special template having a diameter not less than 75 percent of the inside diameter through PVC conduits to insure that the conduit is clean and free from obstructions. A nylon or non-metal pull tape shall be used in pulling cable and conductors through PVC conduit. Metal tapes will not be permitted in PVC conduit. The conduits shall be placed as shown on the drawings or as directed by the Engineer.

Conduit placed for concrete encasement shall be secured and supported in such a manner that the alignment will not be disturbed during placement of the concrete. No concrete shall be placed until all of the conduit ends have been capped and all box openings closed.

PVC conduit which is placed under existing pavement, sidewalks, and driveways shall be placed by first providing a void through which the PVC conduit shall be inserted. Boring is required for placing conduit under pavements. Metal conduit which is to be placed under existing pavement, sidewalks, and driveways shall be placed by boring.

Existing conduit which has been placed in position on the job site by others for this installation shall be checked to see that there are no obstructions in the conduit prior to threading the wire through. Any such obstructions shall be cleared without damage to the conduit, prior to installing cable.

Conduit runs shall be installed in such a manner as to minimize the accumulation of moisture at low points and pockets.

The components parts of conduits systems shall, in general, be of like material. Where dissimilar metals are used together, suitable provisions shall be made to prevent galvanic action.

The ends of all conduit runs shall be closed immediately after installation to prevent the accumulation of water, dirt and other foreign material. Conduit shall be swabbed out where necessary before conductors are pulled in. Bends may be either factory or field made. All 2 inch conduits shall be placed with special radius sweeps with a minimum radius of 18 inches. Standard bends shall not be allowed with 2 inch conduits.

D. Bonding

A No. 8 solid soft bare copper bond wire shall be installed in each conduit. This bond wire shall be firmly attached to the grounding rod installed in each pull box and cabinet. The bond wire shall create a continuous grounding system for the entire conduit system. All conduits, including rigid metal, shall be bonded together with a No. 8 solid bare copper wire and have continuity to every ground rod installed at each signal installation.

E. Pull Rope

A 5/16 inch nylon pull rope shall be installed in each conduit installed. A minimum of three feet of pull rope shall be coiled in each pullbox and cabinet.

F. Sealing

After installation of cables and wires the conduits shall be sealed with a suitable compound so as to prevent the entrance of moisture or gases.

END OF SECTION

SECTION 16713

PRE-FORMED LOOPS

PART 1 GENERAL

1.01 SECTION INCLUDES

Materials and installation of Pre-Formed Loops.

1.02 SUBMTTALS

A. Contractor shall submit a list of intended suppliers and products to be used for loop and lead-in assembly and splice enclosure. City reserves the right to request actual product samples prior to approval.

1.03 MEASUREMENT AND PAYMENT

A. Measurement
This item will be measured as each loop installed, per size specified in the drawings and made fully functional and tested in accordance with this Section or as directed by the Engineer.

B. Payment
Payment for installation of pre-formed loop will be on the basis of each loop installed.

C. The price is full compensation for furnishing and installing the pre-formed loops. Cost of associated lead-in assembly and splice enclosure will not be paid for directly but is to be included in the unit price bid for installation of each pre-formed loop.

PART 2 PRODUCTS

2.01 MATERIALS

Provide a loop, lead-in cable and splice enclosure that meets the following requirements.

A. General Requirements.

The loop / lead-in assembly shall be suitable for applications in which the loop / lead-in assembly will be overlaid with hot asphalt or embedded in concrete.

B. Loop Cable

Provide a loop cable that has the following futures:

1. The loop Cable shall be a four-conductor, double-jacketed cable with a nominal outer diameter of 0.360".

2. The individual conductors shall be #18 AWG wire (formed from seven strands of #26 AWG copper wire) with a 0.020" thick layer of cross-linked polyethylene (XLPE) insulation.

3. The inner jacket shall be 0.040" thick cross-linked polyethylene (XLPE).

4. The void between the conductors and the inner jacket shall be spiral wrapped with a clear, moisture resistant binder tape and filled with anamorphous water-block compound.

5. The outer jacket shall be 0.035" thick cross-linked polyethylene (XLPE).

C. Lead-in Cable

Provide a lead-in cable that has the following features:

1. The lead-in cable shall be a two-conductor, double-jacketed cable with a nominal outer diameter of 0.360".

2. The individual conductors shall be #16 AWG wire (formed from nineteen strands of #28 AWG copper wire) with a 0.020" thick layer of cross-linked polyethylene (XLPE) insulation.

3. The inner jacket shall be 0.040" thick cross-linked polyethylene (XLPE).

4. The void between the conductors and the inner jacket shall be spiral wrapped with a clear, moisture resistant binder tape and filled with an amorphous water-block compound.

5. The outer jacket shall be 0.042' thick cross-linked polyethylene (XLPE).

D. Cross-linked Polyethylene (XLPE) Insulation

The cross-linked polyethylene (XLPE) insulation used for wire insulation and cable jacketing shall be capable of withstanding temperature up to 426° Fahrenheit.

E. Splices and Enclosure
Splices and enclosure that encapsulates the spliced connections shall have the following additional features:

1. Splices between the individual loop cable conductors and the splices between the loop cable conductors, and the lead-in cable conductors shall be soldered, sealed, and waterproofed.

2. The enclosure that encapsulates the spliced connections shall be fabricated from a high impact glass impregnated plastic with a minimum thickness of 0.240".

3. The two halves of the splice enclosure shall be sealed with a water resistant gasket material.

4. The interior cavity of the splice enclosure shall be **completely** filled with an amorphous water block compound.

5. The splice enclosure shall be submerged in a saltwater solution for three (3) days.

6. At the end of this three days period, the electrical integrity of these splices shall be verified by using a 500 Volt DC MegOhm meter to ensure that the resistance between either lead-in conductor and the saltwater solution is 200 Mega Ohms or greater.

2.02 Loop Installation

A. General.

Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts to maximize standardization.

B. Loop Installation – Asphalt Overlay

1. Place the Pre-formed loop in the proper position and orientation on the asphalt base lift.

2. Route the lead-in cable to the desired termination point.

3. Cut the fiberglass backed mastic tape into 2"x4" or 3'x4" strips. Use the mastic tape (and optional corner brackets) to hold the loop and lead-in cable in place.

4. Apply the top lift, make certain that the loop cable does not get pulled into the augers in the paving machine.

C. Loop Installation – Poured Concrete

1. Place the Preformed Loop in the proper position and orientation on top of the concrete reinforcing steel.

2. Route the lead-in cable to the desired termination point.

3. Cut an appropriate number of ½" poly tees. Cut an equal number of lengths of 3/8" rebar.

4. Use the tees, rebar and nylon cable ties to hold the loop cable in place at least 2" above the concrete reinforcing steel. The lid-in cable can be tied directly to the concrete reinforcing steel.

5. Poor the concrete making certain not to disturb the loop cable.

PART 3 EXECUTION – Not Used

END OF SECTION

SECTION 16715

VEHICLE SIGNAL HEADS (POLYCARBONATE) (ADJUSTABLE, EXPANDABLE TYPE)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polycarbonate Vehicle Signal Heads with mounting attachments and light emitting diode (LED) lamp indications, louvered back plates, and Geometrically Programmed Louvers (GPL).

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Vehicle Signal Heads will be measured by each vehicle signal head assembly required with specified mounting hardware. Vehicle Signal Heads shall consist of one (1) or more sections with visor(s), mounting hardware, LED indication color(s) specified and louvered back plates. The Vehicle Signal Head housings, doors and visors shall be Federal Highway Yellow.

2. Payment for Geometrically Programmed Louver (GPL) and adjustable full-circle visor will be measured as each unit required.

3. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Vehicle Signal Head", of the various configurations complete with LED indication(s) and mounting hardware and louvered back plates as specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. The traffic control signal heads shall be in accordance with the latest revision of ITE Technical Report No. 1.

B. Each traffic signal face shall consist of one or more signal sections rigidly fastened together as per manufacturer's recommendations in such a manner as to present a continuous pleasing appearance.

C. The electric and optical system of the signal head shall, unless otherwise specified, be designed for operation from a power supply of 115 volt, single phase, 60 Hz alternating current and LED displays.

D. Polycarbonate shall be used in fabricating the vehicle signal heads described herein. Structural requirements for polycarbonate materials are described in Paragraphs. 2.02 and 2.03.

E. All material for the mounting attachments shall be metal.

2.02 HOUSINGS

A. The polycarbonate vehicle signal head housing cases shall be a one-piece polycarbonate resin material with sides, top, and bottom integrally molded. The housing shall be injection molded from ultraviolet and heat stabilized flame retardant, permanently colored polycarbonate resins. The housing shall be a minimum of 0.125 inches (3.18 mm) thick measured anywhere on the housing and shall be internally ribbed so as to produce the strongest possible assembly consistent with lightweight. The terminal block shall either be securely mounted or integrally molded into the housing.

B. Provision shall be made for accommodation of the particular type of mounting specified and attachment of doors, optical units, and other such accessories as may be specified for the particular installation. All traffic signal housing cases, together with doors, lenses, and mounting attachments, shall comprise a dust and moisture proof housing for the optical units, connecting wiring, and terminal block. The housing cases shall be of such construction as to assure permanent alignment of the lens in the traffic signal face. Design of door, housing, and visor shall be such that no light is visible in the profile view of the traffic signal face.

C. Vehicle Signal Head housing cases shall be of the sectional, adjustable, expandable type. The assembled housings for each signal face shall consist of three or more individual dual sections, each designed for housing a single complete optical unit. Individual signal sections shall be rigidly attached to form a single head either with at least four machine screws between each section or by the bolt-and-washer conduit method. Complete signal heads shall provide positive locked positioning when used with serrated brackets, mast arm, or span wire fittings.

D. Portions of cases providing for attachment to supporting arms shall be molded with large bosses for the supporting arms. Each housing case shall be so attached to its supporting arm that it will be adjustable by rotation about its vertical axis in such a manner that any pair of adjacent cases may be adjusted individually to give indications in two directions as close as 15 degrees apart and may be rigidly clamped in any position throughout the range of adjustment. Provision shall be made for carrying the traffic signal leads enclosed in the mounting attachment.

E. Both the top and bottom of each traffic signal housing case shall be provided with an opening of two inches (50 mm) in diameter to accommodate 1-1/2" (38 mm) pipe brackets. A locking ring shall be integrally cast or molded around the bottom opening. Around the top opening shall be either an integrally cast or molded locking ring or a separate splined locking ring designed to fit into notches. The locking rings shall have a minimum of 72 evenly spaced teeth and shall be so designed that the top and bottom rings will mate to provide a perfectly aligned signal head with flush connection between the outer circumference of the sections.

F. Any open end of an assembled signal housing shall be plugged with an ornamental cap and gasket of an approved type.

2.03 HOUSING DOOR

A. The housing door of each traffic signal housing shall be a one one-piece polycarbonate resin material with an approximate 12-inch (300 mm) diameter circular opening for the lens as specified. The housing door shall be a minimum of 0.125 inches (3.18mm) thick measured anywhere on the housing door. The door shall be attached to the housing by means of two stainless steel hinge pins.

B. Two stainless steel wing screws shall be installed on the side of the door to provide for opening and closing the door without the use of special tools. Wing screws shall have a flat-bearing surface or stainless steel flat washer to prevent gouging of the housing door by the wing screws. Wing screws shall remain captive in the housing door when the door is open.

2.04 VISORS

A. Each traffic signal housing door shall be equipped with an easily detachable standard tunnel visor (unless requested otherwise). The visor shall be a polycarbonate resin to match the housing and door. The visor shall be rigidly attached to the door with rust-resistant connections in a manner that will prevent the leakage of light and moisture throughout the periphery of attachment.

B. Unless requested otherwise, the visor on the front of each door shall:

1. Be circular in section

2. Have a downward tilt of 2 to 8 degrees

3. Encompass approximately 300 degrees of the lens

4. Extend outward from the face of the lens a minimum of 9-1/2" (240 mm) for 12inch (300 mm) diameter lens, (measured at its outer visible circumference)

5. Be of such design that the encircled portion of the lens will not be visible in

the profile view of the traffic signal face

6. Be open at the bottom so as to prevent the accumulation of snow, dirt, and rain.

C. Visors shall be easily removed and replaced without damage to visor or signal head.

D. The four (4) tabs used to mount the visor to the signal shall be slotted. It shall not be necessary to completely remove the mounting screws to remove or replace the visor.

2.05 OPTICAL SYSTEM

A. The Vehicular Light Emitting Diode (LED) Indications to be furnished with the Vehicle Signal Head shall meet the requirements of Specification Section 16718 - Vehicle Traffic Control Signal Heads.

2.06 TERMINAL BLOCKS AND ELECTRICAL

A. Terminal blocks shall be either two or seven position and be double row, with each section consisting of two 8-32 x 5/16-in. binding screws and a conducting metal strip between the screws.

B. The terminal blocks shall be a one-piece molded construction using phenolic materials, rated for a minimum 20 amps, 250 volt service

C. Each LED module shall be wired to a two position terminal block located in that signal section. A seven position terminal block shall be furnished in the outermost signal section of any 3 or more section vehicle signal head assembly. All sections of the vehicle signal head assembly shall be wired to the seven position terminal block. All terminal blocks shall be securely mounted in an accessible position and shall be of weatherproof-molded construction, equipped with identified terminals. Binding screws shall be provided for the field and interior wires.

D. Maintain throughout the vehicle signal head the color coding for wires from the LED Module to the main terminal block as shown below:

Indication	**Color Code**
Red Ball / Arrow	Red
Yellow Ball	Yellow
Green Ball	Green
Yellow Arrow	Yellow with Blue or White Tracer
Green Arrow	Green with Blue or White Tracer
Neutral White	

2.07 MOUNTING ATTACHMENTS

A. All mounting attachments shall be aluminum. Provision shall be made for carrying the signal leads enclosed in the mounting attachment. The mounting attachment, together with supporting arms and assembled housings, shall comprise a dust-and-moisture-proof enclosure for optical units and lead wiring. Mounting attachments shall be of one of the following types as specified for the particular vehicle signal head required.

1. Span-Wire Mounting. The span-wire mounting attachment shall consist of a cable clamp to receive a suspension cable of 3/8" (10 mm) diameter together with a suitable connection to the signal head. The mounting shall provide a "balance adjuster" between the signal head and span wire capable of permitting freedom of movement with reference to the point of suspension. The signal head shall be adjustable by rotation about its vertical axis in a horizontal plane and the mounting attachment shall be so constructed that the head may be firmly clamped in any position throughout the range of adjustment. The mounting shall provide a suitable outlet for wiring from the signal head tilted downward and so constructed as to effectively seal the interior of the head from dust and moisture and prevent undue abrasion of signal wiring. Mountings for signal head units not balanced at the point of support shall be provided with a suitable compensating device to insure that the signal head will assume a normally vertical position. The mast-arm vehicle signal head mounting hardware shall be Astro-Brac Atlas Large Capacity Cable Mount assembly, or approved equal.

2. Mast-Arm Mounting. The mast-arm vehicle signal head mounting hardware shall be Astro-Brac Atlas Large Capacity Tenon Mount assembly, or approved equal.

3. Side-of-Pole Mounting. Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arms, attached to the top and bottom of the signal head with pipe nipples, serrated elbows and collared / cast nipples and band-on pole plates. Pole plates shall be provided with a cable guide. The mounting assembly shall consist of two standard pipe sections extending 12- 3/4" from and at right angles to the axis of rotational adjustment of the signal head. Both supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top or bottom support.

2.08 LOUVERED VEHICLE SIGNAL HEAD BACK PLATE

A. The back plate shall be attached to all new vehicle signals. Back plate shall be continuously louvered around its perimeter.

B. Back plates shall be vacuum formed ABS plastic or aluminum.

C. Vacuum formed ABS plastic back plates shall contain ultraviolet inhibitors and stabilizers for protection against UV degradation

D. The back plate shall extend around the periphery of the signal face a distance of five (5) inches for faces with twelve (12) inch lenses, and shall have a 3" corner radius.

E. ABS vacuum formed back plates shall be black and color consistent throughout the entire piece without varying shades and tones.

F. The louvers shall be evenly spaced around the back plate, including the top and bottom. The number of louvers adjacent to the vehicle signal head shall be nine (9) per signal section per side. Both the top and bottom back plate sections shall have nine (9) louvers each. The louvers shall be at least 3-1/2" long by 5/8" wide with an opening of at least ¼". The back plate shall be pre-drilled to fit the vehicle signal head for which it is designed.

G. ABS vacuum formed back plates shall have a minimum thickness of .125". All outside edges shall be formed with a ½" to 5/8" flange (inside dimension) turned away from the front surface. The back plate shall have a haircell finish on the front side and smooth finish on the back side.

H. Aluminum back plates shall be fabricated from anodized sheet aluminum and be painted dull black.

I. Stainless steel hardware for attaching the back plate to the vehicle signal head shall be provided.

2.09 GEOMETRICALLY PROGRAMMED LOUVER (GPL)

A. The louver shall have the following capabilities:

1. Fit all manufacturers' 12" vehicle signal heads.

2. Retrofit into existing 12" vehicle signal heads.

3. Provide a full round ball display, with minimum slat effect, throughout the selected view range.

4. Provide an absolute exact visual cut-off.

5. Allow the view angle within each signal section to be adjusted to a designated area.

6. Have minimum glow outside the view range.

7. Allow for controlling either the horizontal or vertical view range within the signal visor.

B. The louver housing shall consist of a two-piece assembly injection molded from black UV inhibited ABS plastic. Two (2) brass inserts shall be molded into the bottom half allowing the assembly to be fastened together with two (2) stainless steel screws.

C. The louver housing O.D. shall be 11-1/2" and have spherical contour which allows the light beam from the signal section to be directed up to 10-degrees in all directions from the centerline of the visor/lens system.

D. The inside surface shall have a multiplicity of grooves for positioning light directing baffles. The remaining inside surface shall be grooved to prevent surface reflections of light.

E. Two (2) sponge neoprene O-rings shall be positioned in grooves on the outside surface to prevent light leakage between the housing and the visor.

F. The louver housing design shall allow the baffle positions to be changed in order to adjust the view angle.

G. The baffles shall be molded from flat black, 10% glass filled UV inhibited virgin polycarbonate.

H. Each baffle shall be thin opaque disc with a multiple of parallel evenly spaced apertures (openings). Each structural member forming the aperture shall have a cross section which allows for good stiffness and structural integrity, but shall have a thin edge to prevent reflection (glow) outside the desired viewing range.

I. All baffles shall be identical in design and interchangeable within the housing. The plane of each baffle shall be 90-degrees to the centerline axis of the housing.

J. The louver shall be supplied with the necessary self-threading screw hardware to attach the louver to the vehicle signal head visor.

K. The louver shall include an installation kit that includes installation instructions, adjustment tool, visor marking template, and all incidentals necessary for attachment and positioning of the louver.

PART 3 EXECUTION – Not Used

END OF SECTION

SECTION 16719

COUNTDOWN PEDESTRIAN SIGNAL MODULE

PART 1 GENERAL

Furnish LED countdown pedestrian signal modules that conform to the following:

A. Manual on Uniform Traffic Control Devices (MUTCD)
Control Signal Indications (PTCSI).

B. Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 on the Emission of Electronic Noise.

1.01 MATERIALS

The items furnished and installed under this contract shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship. Manufacturers furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

1.02 UNIT IDENTIFICATION

Units shall be clearly marked on the back surface of the unit in a permanent manner showing information required for warranty and long term performance. Information to be shown shall include manufacturer name, date of manufacture, electric power requirements, model type, and serial number

1.03 SILENCE OF SPECIFICATIONS

The apparent silence of these specifications as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.04 TEST EQUIPMENT

Suppliers/manufacturers shall furnish with their bid a complete description and cost of any special test equipment that is necessary to install, operate, or maintain its equipment.

1.05 UNIT PRICES

A. Measurement
This item will be measured as by each countdown pedestrian signal module complete in place.

B. Payment
The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Countdown Pedestrian Signal Module". This price shall be full compensation for furnishing, assembling, and installing the countdown signal, and for all mounting attachments, labor, tools, equipment, and incidentals necessary to complete the work.

PART 2 PRODUCTS

Upon request, one schematic wiring diagram and installation manual shall be provided with each LED module.

2.01 MATERIALS

A. Countdown Pedestrian Signal Module

1. The message-bearing surface of the module shall be supplied with a fully populated "HAND" and "MAN" symbol, overlapping, that comply with PTCSI Standard for these symbols for a message-bearing surface of the size specified.

2. The LED module shall display a solid Portland orange hand and lunar white man and two Portland orange countdown numbers.

3. The numbers 00 to 99 on the numerical display shall have 2 rows of LEDs, that are side by side, not offset, and a minimum height of 9 inches.

4. The LED countdown pedestrian signal module shall be a single, self-contained device.

5. Portland Orange (amber hand and countdown numbers) LEDs shall be "AlInGaP" (Aluminum Indium Gallium Phosphorus) technology or equal, and rated for 100,000 hours or more of continuous usage at 25ºC and 20 mA. White LEDs shall be InGaN (Indium Gallium Nitide) technology.

6. The assembly and manufacturing process for all internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

7. The signal module shall be made of UL94VO flame-retardant materials. The lens is excluded from this requirement.

8. The lens of the LED pedestrian and countdown signal modules shall be polycarbonate UV stabilized.

9. The exterior of the lens of the LED countdown pedestrian signal module shall be uniform and frosted to reduce sun phantom effect.

10. Each individual LED traffic module shall be identified for warranty purposes with the manufacturer's trade name, serial number and operating characteristics, i.e., rated voltage, power consumption, and volt-ampere.

11. LED countdown pedestrian signal modules shall fit into traffic housings built to the VTCSH Standard without any modification to the housing.

12. Lens must diffuse the LED array over the entire surface of the lens.

B. ENVIRONMENTAL REQUIREMENTS

1. The LED pedestrian and countdown signal modules shall be rated for use in the ambient operating temperature range of -40ºC to +60ºC (-40ºF to +140ºF).

2. The LED pedestrian and countdown signal modules, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA Standard 250-1991, sections 4.7.2.1 and 4.7.3.2, for type 4 enclosures to protect all internal LED, electronic, and electrical components.

C. ELECTRICAL REQUIREMENTS

1. The secured, color coded, 914 mm (36 in) long, 600V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105ºC, are to be provided for electrical connection.

2. The LED pedestrian and countdown signal module shall operate from a 60 ±3 Hz AC line over a voltage range of 80 to 135 volts rms. Variations in the voltage range shall have a minimal impact, less than 10%, on the luminous output of the module. Rated voltage for all measurements shall be 120 ±3 volts rms.

3. The LED circuitry shall prevent perceptible flicker over the voltage range specified above.

4. Transient Voltage Immunity: The modules shall be tested for transient immunity, at minimum amplitude of 2000 volts, using the procedure described in Section 2.1.8, NEMA Standard TS 2-2003.

5. Catastrophic failure of one LED light source in Man & Hand Symbol shall not result in the loss of more than the light from the one display segment.

6. The LED pedestrian and countdown module shall be operationally compatible with the currently used controller assemblies. The LED pedestrian and countdown module shall be operationally compatible with conflict monitors.

7. The LED pedestrian and countdown module including its circuitry must meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

8. The LED pedestrian and countdown module shall provide a power factor of .90 or greater when operated at the nominal operating voltages, and 25 degrees C (77 degrees F).

9. Total harmonic distortion (current and voltage) induced into an AC power line by an LED pedestrian and countdown module operated at the nominal operating voltages, and 25 degrees C (77 degrees F), shall not exceed 20 percent.

D. INPUT PROTECTION (optional)

At the point of entry to the module for each input provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC – (between the resistor & arrestor).

E. PHOTOMETRIC REQUIREMENTS

1. Luminance

For a minimum period of 60 months, the maintained minimum luminance values for the modules under the operating conditions defined in Sections 3.3.1 and 5.2.1, when measured normal to the plane of the icon surface, shall not be less than:

Walking person: 2,200 cd/m^2
Hand: 1,400 cd/m^2

The luminance of the emitting surface, measured at angles from the normal of the surface, may decrease linearly to a value of 50% of the values listed above at an angle of 15 degrees.

The light output requirements in this specification apply to pedestrian signal heads without any visors, hooded or louvered (egg-crate). Addition of such visors may affect the light output of the signal head, and the purchasing agency may wish to consult the issue with the manufacturer.

2. Uniformity and Distribution

The uniformity of the walking person and hand icons' luminance shall meet a ratio of not more than 1 to 5 between the minimum and maximum luminance values, as measured in 12mm (0.5 in) diameter spots.

When operating within the temperature range specified in Section B1, the average luminance of the module shall not exceed three times the maintained minimum luminance of the modules, as defined in Section D1.

3. Chromaticity

The standard colors for the LED Pedestrian Signal Module shall be White for the walking person and Portland Orange for the hand icon. The colors for these icons shall conform to the following color regions, based on the 1931 CIE chromaticity diagram:

Walking Person—
White: Blue boundary: $x = 0.280$.
1st Green boundary: $0.280 \leq x < 0.400$
$y = 0.7917 \cdot x + 0.0983$.
2nd Green boundary: $0.400 \leq x < 0.450$
$y = 0.4600 \cdot x + 0.2310$.
Yellow boundary: $x = 0.450$
1st Purple boundary: $0.450 \leq x < 0.400$
$y = 0.4600 \cdot x + 0.1810$.
2nd Purple boundary: $0.400 \leq x < 0.280$
$y = 0.7917 \cdot x + 0.0483$.

White Point	*x*	*y*
1	0.280	0.320
2	0.400	0.415
3	0.450	0.438
4	0.450	0.388
5	0.400	0.365
6	0.280	0.270

Hand—Portland Orange:
Yellow boundary: y = 0.390
White boundary: 0.600 ≤ x ≤ 0.659 y = 0.990 – x Red boundary: y = 0.331.

Portland Orange Point	x	y
1	0.6095	0.390
2	0.600	0.390
3	0.659	0.331
4	0.669	0.331

4. Color Uniformity

The uniformity of the emitted colors shall be such that any color measurement within a 12mm (0.5 in) spot on the emitting surface shall fall within the following regions around the average measured color of the entire emitting surface:

• Walking Person—White:

where Δx and Δy are the differences in the chromaticity coordinates of the measured colors to the coordinates of the average color, using the CIE 1931 Chromaticity Diagram and a 2 degree Standard Observer.

• Hand—Portland Orange:

The dominant wavelength for all individual color measurements shall be within ±3 nm of the dominant wavelength for the average of all the individual color measurements.

F. FUNCTIONAL REQUIREMENTS

1. Basic Operation
The control and regulation module shall allow for the countdown displays to be automatically adjusted with the programmed intervals of the traffic controller.

2. Operating Modes
   The module shall operate in one mode:
   a. Clearance Cycle Countdown Mode – The module will start counting when the flashing clearance signal turns on and will countdown to "0" and turn off when the steady "Don't Walk" signal turns on.

3. Power Failures
   The equipment must maintain a consistent countdown during short power failures (<1 second). A longer failure or an absence of signal superior to one (1) second must turn off display and trigger a restart system remembering the last sequence, as it is done for the NEMA traffic controller.

PART 3 EXECUTION

3.01 PRODUCT TEST AND INSPECTION

Upon final delivery The City of Houston shall randomly select two modules of each type and deliver City of Houston approved testing laboratory. Said modules shall be subjected to testing according to Part 2.C.4 with all associated costs including shipping to be born by supplier. Any quality issues resulting from these tests will result in rejection of whole shipment.

3.02 WARRANTY

A minimum guarantee for both materials and workmanship shall be provided by the Contractor for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

A. Warranties and Guarantees

1. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of sixty (60) months. Warranty period shall begin the day the LED signal module is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective LED signal module. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then

   Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

2. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee period. Any

work done by the City will be at a rate of $40 per labor unit.

3. Modules which exhibit luminous intensities less than the minimum values specified within the first 36 months, of the date of delivery, shall be replaced or repaired.

4. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. Optical testing shall be performed with the LED module mounted in a standard pedestrian signal unit. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

5. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

6. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost.

7. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or City's Traffic Engineer's representative, on any special circuitry that may be required in certain applications.

END OF SECTION

SECTION 16720

TRAFFIC SIGNAL CABLE

PART 1 GENERAL

1.01 SECTION INCLUDES

This specification describes minimum requirements for traffic signal control cable and/or wire used in City of Houston traffic signal installations. The cables shall conform to specification requirements of the International Municipal Signal Association (IMSA) for the specific type cables included in the bid form, and THW wire shall conform to industry standards. These specifications and standards are included in this specification by reference. An informational copy of IMSA specifications is available for inspection at the Traffic Operations Center, 2200 Patterson, between the hours of 8:00 AM and 3:00 PM, Monday through Friday, except holidays.

1.02 SILENCE OF SPECIFICATIONS

The apparent silence of these specifications as to any detail, or the apparent omission from it of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.03 UNIT PRICES

A. Measurement
This item will be measured by the linear foot of traffic signal cables, as per the various sizes and types shown on the drawings. Measurement will not be made for cable inside signal heads and controllers and cable coiled pull boxes, in pole bases and coiled on span wires.

B. Payment
The work performed and materials furnished in accordance with this item and measured as provided under “Measurement” will be paid for at the unit price bid for “Traffic Signal Cables” of the various types and sized specified. This price shall be full compensation for furnishing and installing all materials, and for all, tools, equipment and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

The items furnished shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship. Manufacturer furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

2.02 INSULATION

Insulation compound and thickness for each conductor shall conform to the specification requirements as specified for each item of the bid form.

2.03 JACKET

Jacket compound and thickness for multi-conductor cable shall conform to the specification requirements as specified for each item of the bid form.

2.04 VOLTAGE RATING

All cables and/or wire furnished shall be rated at 600 Volts.

2.05 CONDUCTORS

Copper used to form the conductors shall be soft or annealed copper and shall be formed as solid or stranded conductor(s) as specified for each item of the bid form.

2.06 CONDUCTOR IDENTIFICATION AND CABLE MARKER

Each conductor shall be identified by color-coding conforming with specification requirements specified for each item of the bid form. Each cable shall be identified at maximum 2-foot intervals with manufacturers name and year of manufacture.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Test and Test Methods
All cables and/or wires shall be sampled and tested at the factory to determine their compliance with specification requirements as specified for each item of the bid form.

END OF SECTION

SECTION 16724

EMERGENCY VEHICLE PREEMPTION (EVP)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The system employs optical communication to identify the presence of designated emergency vehicles and causes the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. The matched set of components which make up the system will cause the existing traffic controller to be manipulated upon recognition of the signal from the vehicle. This communication is effective to the optical detectors at or near the intersection over a line-of-sight path of up to 1800 feet.

The system requires no attention of the vehicle operator other than a simple emitter "ON" switch located in the vehicle which is to remain "ON" until the end of the emergency run. The system shall operate on a first-come, first-served basis. The system is capable of overriding lower priority systems of similar nature while yielding priority to activity such as railroad, drawbridge, etc. The system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions.

The EMERGENCY VEHICLE PREEMPTION (EVP) consists of optical emitter assemblies, optical detectors, optical detector cable, phase selectors, preempt module and card rack. The EVP Intersection Components are the optical detectors, optical detector cable, phase selectors, preempt module and card rack. Emitter assemblies will be supplied by the Contractor only when specifically called out on the plans.

1.02 SILENCE OF SPECIFICATIONS

The apparent silence of these specifications as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. This item will be measured by each intersection of the required optical detectors, optical detector cable, phase selectors, preempt module and card rack complete in place.

2. The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Emergency Vehicle Preemption". This price shall be full compensation for furnishing, installing and testing the system; and for all labor, tools, equipment and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

The items furnished and installed under this contract shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship. Manufacturer(s) furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

2.02 MATCHED SYSTEM COMPONENTS

The City of Houston EVP is comprised of four basic matched components. To ensure system integrity, operation and compatibility, the four basic components (optical emitter, optical detector, detector cable, phase selector) shall be from the same manufacturer. The bidder shall supply and install the optical detector(s), detector cable, and phase selector for each intersection called for on the plans.

The bidder of the Emergency Vehicle Preemption equipment shall provide with the bid written certification from the manufacturer that the system components were designed, manufactured and tested as a system of matched components and will meet or exceed the requirements of this specification and work with the existing City of Houston optical emitters.

2.03 SYSTEM OPERATION

A. Priority control phase selection shall be activated by an optically transmitted signal of 14.035 HZ or 9.639 HZ, or upon the activation of a test switch.

B. The traffic controller shall receive inputs from the preempt module upon activation of the appropriate signal from the phase selector.

C. The system shall provide power for up to three optical detectors for each priority channel. The system shall maintain continuous communication between the optical emitter equipped vehicle and the traffic controller.

D. The system shall allow the traffic signal controller to resume normal timing operation after the optical signals cease for an appropriate period.

E. The system shall not attempt controller manipulation nor retain priority vehicle calls during periods of "intersection flash" or "railroad preempt" operations.

2.04 SYSTEM COMPONENT SPECIFICATIONS

A. Optical Emitter Assembly

1. The assembly shall include an optical energy emitting unit for mounting to the exterior of the vehicle, an emitter control switch for mounting to the interior dash or instrument panel, and all necessary wiring and hardware for a typical installation.

2. The optical emitter assembly shall operate over an ambient temperature range of -30 degrees F (-34 degrees C) to up to 140 degrees F (+60 degrees C).

3. The optical energy emitting unit shall contain an internal regulated power supply to convert 12 VDC (positive or negative ground) vehicle battery power to high voltage required for the flashtube and meet the following electrical requirements:

   a. Operational at 10 volts DC to 15 volts DC,

   b. Have internal protection for a sustained input voltage of up to 25 volts DC,

   c. Deliver sufficient optical energy to activate the optical detector from a distance of 1800 feet, and

   d. Consume no more than 40 watts.

4. The optical energy emitting unit shall weigh not more than 4.5 pounds.

5. The optical energy emitting unit shall not exceed the following physical dimensions:

   a. Length - 5.25 inches,

   b. Width - 7.0 inches, and

   c. Height - 6.63 inches.

6. The optical energy emitting unit shall be capable of producing precisely-timed pulses of high intensity light in response to a low voltage trigger signal from the crystal controlled emitter control switch.

7. The optical energy emitting unit shall be controlled by a single ON/OFF switch which requires no warm-up, setting, or adjustments by the vehicle operator. An indicator located adjacent to the ON/OFF switch shall identify that the crystal controlled timing circuitry is energized.

8. The emitter control switch shall produce crystal controlled low voltage trigger pulses to the optical energy emitting unit. For high priority/Class II applications, the frequency of the trigger pulses shall be 14.035 +/-0.255 HZ. For low priority/Class I applications, the frequency of the trigger pulses shall be 9.639 +/-0.119 HZ.

B. Optical Detector

1. The optical detector shall be a lightweight, weatherproof device capable of sensing and transforming pulsed optical energy into electrical signals for use by the phase selection equipment.

2. The unit shall be high impact polycarbonate construction with stainless steel and/or brass hardware.

3. The unit shall be designed for mounting at or near an intersection on a mast arm, pedestal, pipe, or span wire.

4. The unit shall accept optical signals from two directions and provide a single electrical output signal.

5. The unit shall include a design feature to allow aiming of the two optical sensing inputs for skewed approaches or slight curves.

6. The unit shall have a built-in terminal strip to simplify wiring connections.

7. The unit shall receive power from the phase selector and have internal voltage regulation to be operational from 16 to 40 volts.

8. The unit must be responsive to the optical emitter at a distance of 1800 feet.

9. The unit must deliver the necessary electrical signal to the phase selector via up to 1000 feet.

10. The unit shall employ a replaceable circuit board assembly and photocells to facilitate repair.

C. Optical Detector Cable

1. The cable must guarantee delivery of the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1000 feet.

2. The cable must guarantee sufficient power to the optical detector over a non-spliced distance of 1000 feet.

3. The cable must be of durable construction to satisfy the following installation methods:

   a. Direct burial,

   b. Conduit and mast arm pull, and

   c. Exposed overhead, supported by messenger wire.

4. The weight shall not exceed .04 lbs/ft.

5. The outside diameter shall not exceed 0.3 inches.

6. The insulation rating shall be 600 volts minimum.

7. The temperature rating shall be 80 degrees C minimum.

8. The cable shall have three conductors of AWG #20 (7x28) stranded, individually tinned copper, color coded insulation as follows:

   a. Orange for delivery of optical detector power,

   b. Blue for optical detector power return, and

   c. Yellow for optical detector signal.

9. The conductors shall be shielded with aluminized polyester and have an AWG #20 (7x28) stranded and individually tinned drain wire to provide signal integrity and transient protection.

10. The shield wrapping shall have a 20% overlap to ensure integrity following conduit and mast arm pulls.

D. Phase Selector

1. All phase selectors shall be digitally controlled and be capable of providing high and low priority operations.

2. The unit shall be a plug-in, two-channel, dual priority device intended to be installed directly into a card rack wired into the traffic signal cabinet.

3. The unit shall be powered from 115 volts, 60 HZ mains and contain an internal, regulated power supply to support optical detectors.

4. The unit shall be capable of recognizing the following pulse rates as delivered by the optical detectors:

   a. 9.639 HZ +/-.119 HZ as low priority (Class I), and

   b. 14.035 HZ +/-.255 HZ as high priority (Class II).

5. The primary optical detector inputs and power outputs shall be on the card edge. Two additional detector inputs, per channel, shall be provided via a front panel connector.

6. One opto-isolated NPN output per channel shall be delivered to the appropriate channel pin on the card edge connector as follows:

   a. HZ +/-.02 HZ 50% on duty square wave in response to a Class I call, and

   b. A "Steady On" in response to a Class II call.

7. The unit shall utilize crystal control timing and optical pulse rate recognition circuitry to assure:

   a. Accurate optical signal recognition for dual priority,

   b. Synchronous logic,

   c. Precise output pulse, and

   d. Accurate call dropout time.

8. The unit shall have six recessed range controls per channel, three for low priority and three for high priority, to adjust optical sensitivity (emitter range).

9. The unit shall have a solid state "Power On" indicator.

10. The unit shall have a "Class I" and "Class II" solid state indicator for each channel which performs as follows:

    a. Flash during call validation, and

    b. Be steady-on during valid call and test switch operations.

11. The unit shall have a test switch for each channel to deliver Class I or Class II signal pulse rates to verify proper function at both optical emitter flash rates, first-come, first-served operation, and Class II override capability.

12. The unit shall have a selectable call dropout time of 5 seconds or 10 seconds.

13. The unit shall properly identify a high priority (Class II) demand with any combination of up to 10 high and low priority emitter signals being received simultaneously and asynchronously on either channel.

14. The unit shall not exceed the following physical dimensions:

    a. Length (including handle) - 7.91 inches,

    b. Width - 1.11 inches, and

    c. Height - 4.50 inches.

E. Traffic Controller Preemption Module

1. A traffic controller preemption module shall be supplied in addition to the four basic matched components. This module shall interface between the phase selector(s) and the traffic signal controller to provide dual priority preempt operation.

2. The preempt module shall be a plug-in, microprocessor controlled, 4 input, 13 output, dual priority device.

3. The preempt module shall recognize steady-on (high priority) over-pulsing (low priority) inputs from the phase selector and assign control on first-come, first-serve and, high priority over low priority basis.

4. The preempt module shall recognize input signals from one or two dual priority phase selectors for up to four separate channels of emergency vehicle preemption.

5. The preempt module shall have a delay timer adjustable from 0 to 15 seconds in one second increments. The delay timer, when properly set, will guarantee a minimum green time for the phase or phases being served prior to initiating the preempt operation.

6. The preempt module shall use the standard input functions available on any NEMA type traffic signal controller and shall not cause the controller to abbreviate its programmed yellow or all red clearance times.

7. When the phase selector deactivates its output, the preempt module shall place vehicle calls on all phases of the traffic signal controller and then allow the controller to resume its regular phase sequence.

8. The preempt module shall provide a separate output for "coordination free" to release the traffic signal controller from coordination control during the operation of the EMERGENCY VEHICLE PREEMPTION.

9. The preempt module shall have a separate input that when active shall cause the preempt module to turn off all outputs to allow for railroad or drawbridge operation.

F. Card Rack

1. The card rack shall be a shelf-mounted device designed to accommodate two phase selectors and a preempt module.

2. The rack shall be constructed of 5052 aluminum of .062" thickness and shall not exceed 7.38" W x 4.71" H x 7.13" L. All of the aluminum components consisting of the sides, top, bottom, and front panel shall be clear anodized.

3. The optical detector cable shall terminate on two terminal strips, 4-position, feed-through solder type. The color code and function of each wire shall be clearly silk screened adjacent to each terminal.

4. The front panel of the card rack shall be hinged to provide easy access to the inside of the rack. Machine screws shall be used to secure the front panel when in the closed position.

5. The card rack shall be equipped with a quick disconnect type connector and 6' harness, wired to accommodate the installation of the card rack in a traffic signal cabinet.

PART 3 EXECUTION

3.01 GUARANTEE

A. A minimum guarantee for both materials and workmanship shall be provided by the Contractor for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

1. Warranties and Guarantees

a. Any and all equipment furnished shall be covered by manufacturer's guarantee or warranty for a period of twelve (12) months commencing on final acceptance date with respect to parts, workmanship, and performance of the product.

b. The Contractor shall bear all expenses connected with the return of any equipment which the City deems necessary to return to the Contractor for proper adjustment or repairs during the guarantee period.

END OF SECTION

SECTION 16727

TRAFFIC SIGNAL SAW-CUT LOOP DETECTOR

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Loop Detectors

This specification and detailed drawings describe the materials and installation procedures necessary to install loop detectors in roadways in the City of Houston. Basically, the inductive loop detector consists of a few turns of wire embedded in the roadway pavement which are connected to an electronic component mounted in a roadside cabinet. The detector is designed so that the passage of a vehicle over the loop in the pavement modifies the magnetic flux around the resonantly tuned loops of wire which is sensed by a transistorized unit that transmits the vehicle presence or passage to the traffic signal controller. Since traffic signal timing and sequencing are totally dependent on the quality and placement of the loops, craftsman type skills must be exercised on installation procedures. Loops may be adjusted by the Engineer, as necessary.

B. Card Rack Amplifiers

These specifications define the minimum acceptable design, operational and functional performance requirements for high performance, two-channel inductive loop vehicle detector units and data acquisition software that can provide binned traffic data and real-time traffic measurements on a vehicle-by-vehicle basis. The system shall provide current measurements and vehicle detection information on the last vehicle for use in local control, incident detection and advanced traffic management systems.

1.02 UNIT PRICES

A. Measurement

This Item will be measured by the linear foot of sawcut containing loop wire and by each two (2) channel detector amplifier. Deviation of the Contractor from the layout on the drawings will require prior approval of the Engineer.

B. Payment

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Loop Detector Sawcut” for the various sizes and types of loop detectors specified on the drawings furnished and installed. This price shall be full compensation for furnishing,

installing and testing the loop detectors; and for all labor, tools, equipment and incidentals necessary to complete the work.

Loop detector amplifiers as measured under "Measurement" will be paid for at the unit price bid for "Two Channel Detector Amplifiers" furnished and installed. This price shall be full compensation for furnishing, installing, and testing the loop detector amplifiers.

PART 2 PRODUCTS

2.01 LOOP DETECTOR MATERIALS

A. Contractor shall set up an adequate and safe traffic control based upon the Texas Department of Transportation Standard Drawing, "BARRICADES, CONSTRUCTION SIGNS AND TYPICAL CONSTRUCTION LAYOUTS FOR TRAFFIC SIGNAL INSTALLATIONS," I-82-8011 BTS and the Texas Manual on Uniform Traffic Control Devices, latest revision.

B. Contractor shall draw all loop outlines on pavement for approval by the Engineer, prior to beginning sawcut.

C. As a minimum requirement, Contractor shall use a self-propelled power saw with diamond blade or abrasive saw blades for sawing the pavement to the length, depth and width as shown on the intersection layout plan and the typical detail drawings. The power saw must be equipped with a depth measurement device, water valve and guide.

D. Contractor shall locate water supply (hydrant or water truck) to cool the blade and to clean out slots. Hydrant can only be used if proper permission has been obtained and water meter is used.

E. Contractor shall have an air compressor for the cleaning and drying out the sawed slots on site.

F. Drill hole through pavement for conduit to pull box.

G. Flexible embedding sealer shall meet the following minimum specifications:

1. The flexible embedding sealer shall be designed to enable vehicular traffic to pass over the properly filled saw cut immediately after installation without tracking or stringing of the material. The flexible embedding sealer shall form a surface skin allowing exposure to vehicular traffic within 30 minutes at 75 degrees F. And completely cure to a tough, rubber-like consistency in two to seven days after installation.

2. Properly installed and cured flexible embedding sealer shall exhibit resistance to effects of weather, vehicular abrasion, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals and salt normally encountered, in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

3. Flexible embedding sealer shall be applicable to both Portland cement concrete and asphalt concrete pavements.

4. The flexible embedding sealer shall exhibit minimal shrinkage during or after its installation, and in no manner affect the performance characteristics of the material.

5. The flexible embedding sealer shall be designed to permit clean-up of material and application equipment with non-flammable solvents such as l.l.l. trichloroethane or Scotch-Grip Brand Solvent No. 4 (Prior to curing of flexible embedding sealer)). Should any flexible embedding sealer material be allowed to cure in the application nozzle, it shall be able to be pulled our as a solid plug.

6. The flexible embedding sealer shall have a minimum 12 month shelf life in undamaged original containers when stored in a cool, dry environment.

7. The flexible embedding sealer shall be designed for roadway installation when the surface temperature is between 40 degrees F and 140 degrees F.

8. The flexible embedding sealer shall have the following physical properties in its uncured and cured states.

Physical Properties of the uncured (wet) flexible embedding sealer:

Property	**Requirement**	**Test Procedures**
Weight	10.1 lbs/gal (+/- 0.5 lbs)	Weight/Gallon
Viscosity	10,000-85,000 CPS	Viscosity
Drying Time	24 hrs. (max)	Tack-Free Time
Skinning Time	6 hrs.	

Physical Properties of the cured flexible embedding sealer:

Property	**Requirement**	**Test Procedure**
Hardness (Indentation)	65-85	Rex Hardness
Tensile Strength	700 psi (min.)	Tensile & Elongation
Elongation	250%	Tensile & Elongation

H. Loop wire shall be IMSA Spec. No. 51-5-1985, #14 AWG, copper, stranded, single conductor pvc/nylon-with tube jacket. The maximum O.D. of the entire cable shall be 0.260 inches.

I. Contractor shall obtain megger and ohm meter for checking integrity of loop insulation and the continuity and resistance of the wired loop.

1. Wire must have a megger reading before installation (on reel);

2. Megger reading after installation (before being sealed);

3. Megger reading after being sealed and splices made;

4. It shall be the Contractor's responsibility to obtain these readings and have them available for the signal inspector upon request.

J. Splicing kit materials and equipment for splicing the two #14 wires to the shielded balanced pair cable in the pull box. Only soldered connections are acceptable. All splices must be watertight. The drain wire of the loop lead-in cable shall be grounded to earth ground only at the controller or detector cabinet. The resistance from the drain wire to the ground rod shall be less than one (1) ohm, at the cabinet.

K. The loop wire shall be held in place every two (2) feet with strips of rubber, neoprene flexible tubing or polyethylene foam sealant, one (1) inch in length. These strips shall be left in place and slot filled with loop sealant.

L. All wires shall be tagged to identify the loop number and lane. The tag identification shall correlate with the electrical schedule shown on the project plans. The tags shall be furnished and installed by the Contractor. Each tag shall be wrapped around the conductor twice. Wire marking tags shall be made of flame retardant reinforced epoxy tape 5.5 mils in thickness and ¼ inch minimum width. The tape shall be flexible and resistant to oil and water, and have a pressure sensitive acrylic adhesive backing. The adhesive shall be a high tack adhesive with good adhesion to clean neoprene, hypalon, nylon and PVC insulation materials. The film material shall conform to the flame retardant requirements of UL 510 and be rated at 150 degrees Centigrade. Appropriate numbers and letters shall be printed on wire tags for conductor identification.

2.02 CARD RACK DETECTOR AMPLIFIER

A. General Design Requirements

1. A communication link shall provide remote access to the detector for reading unit configuration settings, for fault identification and verification, for real-time system monitoring and data collection on up to two channels of detection. It shall include password security to the detector to change configuration settings. The communication link shall provide for party line communication on up to eight units using 4-bit hardwired addresses to the card edge connector and/or 127 software programmable addresses in EEPROM memory.

2. The interface and data acquisition software shall be organized by application and facilitate setup, real-time traffic monitoring and collection of binned count and occupancy data. A vehicle log shall provide a means for logging of vehicle speed, vehicle length, loop-to-loop travel time and detection duration. Optional modes of operation shall include a vehicle travel direction detection setup capability using overlapped 6-foot by 6-foot loops, a long-loop count mode to provide turning movement counts and a microloop mode selection when channels are connected to microloop sensors.

3. The successful bidder or contractor shall supply data acquisition and interface software and vehicle detectors that meet all the operational and functional performance requirements in accordance with the terms and conditions of this specification.

4. The bidder or contractor shall be responsible for any testing, rework and/or re-testing of equipment delivered under this contract that may be required to meet these specifications, at no expense to the City of Houston.

5. The bidder’s documentation shall indicate the manufacturer's name, address, model numbers, and include the shipping address for warranty repair work, as required in these specifications.

6. The City of Houston shall not be required to pay for software and/or hardware related modifications or changes and/or for associated labor that is required to correct errors.

7. The City of Houston shall be required to pay for any software and/or hardware-related modifications or changes and/or for associated labor that result from requested options, features or enhancements.

8. The City of Houston shall have the option to request and provide the communication protocols to a professional engineering consultant or OEM for integrating the data acquisition and interface software into its advanced traffic management system.

9. Serial numbers shall be clearly legible and permanently placed on each inductive loop detector unit.

10. Detectors shall be warranted against defects in workmanship or materials for five (5) years from date of purchase.

B. General Hardware - Standards and Performance Requirements

1. The inductive loop detector units shall be fully interchangeable, whether used for system counting, occupancy measurement, speed and length measurement, directional detection, binned data collection, remote data acquisition in advanced traffic management systems or for local intersection control (including long-loop counting).

2. Detector configuration data shall be entered using special interface and data acquisition software. A communication interface shall provide for remote connection and configuration of detectors, real-time activity monitoring and data acquisition via modem to remote devices.

3. Inductive loop detector units shall meet the latest edition of the National Electrical Manufacturers Association (NEMA) Standard TS2-1992 for Type 2 controller and cabinet assemblies plus the functional and performance requirements of this specification. The detectors shall be configured as plug-in devices which meet the requirements for NEMA TS2-1992 section 3.2, actuated Type 2 A2 operation and Type 1 A1 operation in 44-pin input files.

4. Detectors shall comply with NEMA TS2-1992 Section 6.5.2.2.1, Table 6.5-1 for four-channel rack mount type units, NEMA designation "D," except that Delay and Extension Timing shall be provided on two channels in lieu of NEMA TS2- 1992 section 6.5.2.24 requirements.

5. Detectors shall also be suitable for use in California/New York TYPE 170/179 and ATC cabinets with 22-pin input files.

6. Detectors shall detect and hold the presence of all licensable motor vehicles (including small motorcycles). This shall be accomplished, without detecting traffic in the adjacent lane (beyond 36 inches from the loops except as noted below), on the following loop configurations with 100 up to 1000 feet of homerun cable.

   One to six series connected, 6-foot by 6-foot square loops with three turns of #14 AWG wire.

   One to six series connected, 6-foot by 6-foot square loops with four turns of #14 AWG wire.

   A 6-foot wide by 30-foot long loop with two or three turns of #14 AWG wire (when set to detect small motorcycles, may detect adjacent lane traffic).

   A 6-foot wide by 20-foot to 60-foot long quadrupole loop with a winding two- four-two turns of #14 AWG wire. When sensitivity is set to detect small motorcycles, adjacent lane traffic shall not be detected.

Single, double and triple microloop probe sets.

7. The detection performance described above shall be accomplished when using lead-in/homerun cable lengths of from 50 feet to over 1,000 feet of #14 AWG conductor homerun cable, i.e., International Municipal Signal Association, Specification #50-2.

8. A pushwheel switch shall be provided to allow selection of the threshold/sensitivity setting which will detect and hold presence of all licensable motor vehicles (including motorcycles), without detecting vehicles, moving or stopped, in the adjacent lane (36 inches from the loop connected to this channel, except as noted in 2.1.6.3).

9. Each channel shall automatically self tune with full sensitivity, to any loop and lead-in combination resulting in a total inductance of 20 to 2500 microhenries, with a Q factor of five or greater, within four seconds after application of power.

10. Detectors shall track changes in inductive loop or lead-in electrical characteristics that take place when environmental changes occur, which affect inductive loops installed in undamaged pavement, to insure that units operate properly without producing a false indication, a loss of detection or a change in sensitivity due to weather changes.

C. Special Features and Functional Performance Requirements

1. Detectors shall be microprocessor controlled and shall be configurable with manual switch settings and via software settings in EEPROM memory.

2. Detectors shall include eight sensitivity settings (thresholds), in 2:1 steps. Threshold settings shall directly relate to nanohenries of inductance change (Delta L). Detection output shall be based on a response to a change in the inductance which exceeds the Delta L threshold selected. For a given loop type, such as a 6-foot by 6-foot, three-turn square loop, it shall not be necessary to readjust the sensitivity setting to detect a specific vehicle type and/or to get consistent occupancy measurements using a range of lead-in or homerun cable lengths that vary from 100 feet up to 3500 feet.

3. Each detector shall have a single, switched oscillator system to sequentially excite and measure each channel to prevent crosstalk between channels within a unit.

4. Each detector shall have a three-position toggle switch to manually select one of three operating frequencies to reduce crosstalk between detector units. These three frequencies shall also be software selectable.

5. Each detector shall have two serial ports, a front panel RS232 port and transmit/receive pins on the card edge connector, to facilitate serial communication.

6. Each serial port shall have a multi-drop mode and be capable of party line communication with up to eight detectors on the party line.

7. The detector unit shall be designed to accommodate the addition of an optional plug-in communication module to allow expansion of the multi-drop capability to 32 devices on a common serial port bus and convert the rear port into an independent port. With the optional module installed, communication with a PC through the front port shall not interfere with system communication on the rear serial port.

8. Baud rates shall be selectable at 1200, 2400, 4800, 9600, or 19200 BPS using the interface software. With the communication module installed, the baud rates shall be independently settable for the front and rear serial ports.

9. The unit shall be designed to accommodate either an optional plug-in communication module or a plug-in memory module to expand the memory used for on-board count and occupancy binning.

10. The front panel serial port shall have EIA-232 electrical characteristics and shall terminate with a front panel 6-pin circular Mini-DIN connector.

11. A communication cable with a DB-9 female connector (for a computer serial port connection) and a 6-pin Mini-DIN male connector (for the front panel serial port connection) shall be provided with the interface and data acquisition software. The communication cable shall enable direct communication with a remote reporting device or a PC running Windows 95 or Windows NT 4.0.

12. Units shall have software settable addresses from 128 to 254. Address 255 shall be assigned as a "wildcard" to be used only when connected to the front panel port to establish connection and read the correct address from the device.

13. Units shall have 4-bit back panel hardwired addressing capability to allow selection of one of 16 hard-wired addresses. Back panel addressing shall be enabled via the interface software.

14. An external 24VDC Green control input shall be provided to control the output timing. If True (ground level = 0 to +8VDC), the Green input shall disable Delay and enable Extension Timing; and if False (+16 to +30VDC or Open), the Green input shall disable Extension and enable Delay Timing. Software shall provide for an option to disable Green Gating so that Delay or Extension Timing is provided unconditionally.

15. Detector units shall have a Presence or Pulse mode output option. Selection shall be via front panel switches or software settable options.

16. Each channel shall have a pushwheel sensitivity switch to enable manual selection of the output mode and sensitivity (threshold) settings as follows:

    The pushwheel switch shall have an OFF mode position indicated by an "X" marking. This position shall disable each channel's output and front panel Detect and Fault indicators.

    The pushwheel shall have seven Presence mode sensitivity settings.

    The pushwheel shall have eight Pulse mode sensitivity settings. Pulse mode settings shall use a square-wave marking over the channel sensitivity numeral to differentiate from Presence mode settings.

17. Each increase in Presence or Pulse mode settings shall double the sensitivity (reduce the threshold) from the previous setting.

    The highest sensitivity (smallest change) setting shall have a Delta L threshold value of eight nanohenries.

    The lowest sensitivity setting shall have a Delta L threshold of 1024 nanohenries.

18. Presence output shall hold vehicle detection for at least four minutes minimum for small licensed motor vehicles (100cc. motorcycles) and for at least 60 minutes for automobiles before tuning-out vehicles (dropping recognition of vehicle presence) over a 6-foot by 6-foot square loop with three or four turns of wire.

    The presence output shall not tune out when vehicle motion exists (defined as vehicle entry and departures continue every few minutes and vehicles remain present in the sensing zone) for at least 60 minutes.

19. In Fast Recovery mode the channel shall recover to full sensitivity within 750 milliseconds after all vehicles leave the inductive loop sensing zone.

20. Pulse mode shall provide a single, 118±5 millisecond, output pulse in response to an 18-foot long vehicle traveling over a 6-foot by 6-foot loop at eight miles per hour, and for successive vehicles traveling over the same loop at speeds ranging from ten to 100 miles per hour, with a one second headway. Pulse width shall be programmable from interface software.

If a vehicle remains over the loop, further detection shall be inhibited for a 1.9-second re-phase delay. Then full sensitivity shall return immediately regardless of continued presence of the vehicle. Pulse re-phase shall be programmable from interface software.

21. Detector units shall have optically-isolated FET outputs to provide fail-safe solid state operation (loss of power to the detector will provide a constant call to the controller--if it has power).

22. Loop detector channels shall continue to function with a single point to ground on the loop/lead-in system.

23. Each channel shall have loop measurement capability to continuously verify loop system integrity. The loop detector shall be capable of detecting and displaying current and historical faults (a short to ground, an open circuit or an inductance change ;: 25%) in the inductive loop or lead-in system.

24. Each channel shall have two LED indicator lights on the front panel; a green "Detect" LED and a red "Fault" LED.

25. The green "Detect" indicator shall indicate detection output status and output timing in process.

26. It shall indicate an Extend flash while the call output is actuated following a directional detection.

27. The green "Detect" indicator shall flash during Delay and Extension Timing to provide a visual indication of timed output.

    Delay and Extension flash rates shall differ by at least four times the other's rate. Delay shall be four flashes per second and Extension shall be 16 flashes per second.

28. The green "Detect" indicator shall be ON continuously during a fault condition unless fail-safe for a particular condition is disabled using the interface software.

    During a fault condition on a channel, the channel shall display a continuous call indication on its green “Detect” LED and generate a continuous, fail-safe, output on the primary output, regardless of the Pulse or Presence operating mode selected.

29. A status output shall provide a serial coded message to external devices (controllers) that are capable of using the serial information in accordance with NEMA conventions described in TS2-1992.

30. A red "Fault" LED shall indicate current or historical channel fault condition (status) and type. The Fault indicator shall flash a coded message during an open loop condition, a shorted loop system condition and a ;: 25% change of inductance condition. The associated channel's red "Fault" LED shall provide visual indication of fault type and status as follows:

    OFF state indicates no faults (current or historical).

    ON for one second and one .25 second short pulse indicates a current open loop fault.

    A one second ON and two .25 second short pulses indicates a current shorted loop fault.

    ON for one second and three short pulses indicates a current greater than 25% change in inductance fault.

    A long pulse (six second) followed by a short pulse (.25 second) indicates a historical open.

    A long pulse followed by two short pulses indicates a historical shorted loop.

    A long pulse followed by three short pulses indicates a historical greater than 25% change in system inductance fault.

31. A fault indication shall be enabled for as long as the fault remains, except by turning the channel OFF in software or by selecting the "X" setting on the sensitivity switch.

32. If the fault heals or is corrected, the affected channel shall immediately retune and be capable of normal detection. The visual fault indication shall remain active until reset by a momentary change in the mode or sensitivity setting, a momentary interruption of power or by pressing a reset switch.

33. Call output for each detector channel shall provide detect durations in response to an automobile over a three or four turn 6-foot by 6-foot square inductive loop to enable accurate speed, length and occupancy measurements by external devices.

    The detector with a 100 microhenry loop/lead-in attached to each channel shall, for any negative inductive change which exceeds its sensitivity threshold, generate a ground true logic level output response within 13 milliseconds for a sensitivity setting of 128 nanohenries.

    The detector with a 100 microhenry loop/lead-in attached to each channel shall, for any negative inductive change which exceeds its sensitivity threshold,

generate a ground true logic level output response within 20 milliseconds for a sensitivity setting of 64 nanohenries.

34. The output shall become open within the same time limits when such an inductive change is removed.

35. Loop detectors shall have a multi-position switch to Reset all channels and to provide Normal and Fast Recovery modes of operation.

    The Fast Recovery setting shall cause the detector to adapt instantly to large changes of apparent inductance in the non-call direction.

    The Normal Recovery mode shall cause the detector to adapt, at a default rate of 0.5 thresholds per second, to apparent changes of inductance in both directions.

36. Loop detectors shall have a Remote Reset input pin on the card edge connector. The unit shall reset and establish a new reference for each loop that is turned ON, when voltage on Pin C is less than eight volts DC for a period of greater than 17 milliseconds.

37. Delay Timing shall be adjustable from zero to 31 seconds, minimum, in increments of 1.0 seconds in lieu of NEMA TS2-1992 section 6.5.2.24.1 increments. When Green Gating is enabled (using the interface software) delay timing shall only occur if the green input is false.

38. Extension Timing shall be adjustable from zero to 7.75 seconds, minimum, in increments of 0.25 seconds in lieu of NEMA TS2-1992 section 6.5.2.24.2 increments. When Green Gating is enabled (using the interface software) extension timing shall only occur if the green input is true.

39. Setting the Delay or Extend DIP switches on the printed circuit board to OFF or selecting 0.0-seconds shall disable timing for that channel unless the override switch is off and Configuration Source is selected to be EEPROM using the interface software.

40. Each channel shall be capable of being assigned a Long-loop Count mode using the software.

    Each channel enabled for Long-loop Count mode shall count each individual vehicle moving onto or over a single inductive loop which has a length greater than 20 feet, regardless of previous vehicles being stationary on, moving over or leaving the detection zone.

    Each channel shall be configurable for Long-loop Count mode via the serial communication ports.

The Long-loop Count shall be readable via the serial ports.

The call output in the Long-loop Count mode shall be a Presence output.

41. Two channels (channels 1 and 2) shall be capable of being assigned to Directional Detection mode using the software.

    The two channels shall be capable of detecting the direction of travel of a vehicle over two 6-foot by 6-foot overlapping loops.

    The leading edge to leading edge spacing of the overlapping loops shall be three feet.

    The directional count shall be stored in the detector and shall be accessible via the serial ports.

    The directional count shall be stored in the second channel that detects the vehicle in the direction of the vehicle's travel. A call output shall be generated by the second channel that detects the vehicle in the direction of the vehicle's travel.

42. The vehicle detector unit shall be capable of collecting and storing counts and occupancy in time bins for each channel.

    The time bin interval of the vehicle detector shall be configurable from the serial port using the software.

    The memory of the vehicle detector shall be capable of storing count and occupancy data in 15 minute time bins for all four channels for 36 hours.

    The vehicle detector shall be designed to accommodate a plug-in memory module to expand the on-board memory used for storing the count and occupancy time bins.

    With optional memory module, the vehicle detector shall be capable of storing count and occupancy data in 15-minute time bins for all four channels for 335 hours.

    The count and occupancy stored in the time bins shall be retrievable remotely using the serial ports.

D. Connector Pinout Configuration

The following input-output connector pin terminations shall be provided on input file connectors as well as detector edge connector in accordance to NEMA TS2-1992 section 6.5.2.27.2, Table 6.5.8 requirements.

The detector's edge connector pinout is specified in the table below and is shown looking into the front of a detector card rack or input files. Pin-1 is at the top of the component side of the detector and Pin-A is at the top of the non-component side of the detector.

FUNCTION / SIGNAL	PIN	PIN	FUNCTION / SIGNAL
CH 1 GREEN DC+	1	A	DC GND
CH 2 GREEN DC+	2	B	POWER (+10.8 to 37VDC)
DET ADDRESS 3	3	C	REMOTE EXTERNAL RESET
LOOP IN CH 1	4	D	LOOP IN CH 1
LOOP IN CH 1	5	E	LOOP IN CH 1
DET ADDRESS 0	6	F	CH 1 OUT +
STATUS OUTPUT CH 1	7	H	CH 1 OUT -
LOOP IN CH 2	8	J	LOOP IN CH 2
LOOP IN CH 2	9	K	LOOP IN CH 2
DET ADDRESS 3	10	L	CHASSIS GROUND
NO CONNECTION	11	M	NO CONNECTION
NO CONNECTION	12	N	NO CONNECTION
NO CONNECTION	13	P	NO CONNECTION
NO CONNECTION	14	R	NO CONNECTION
DET ADDRESS 2	15	S	NO CONNECTION
NO CONNECTION	16	T	NO CONNECTION
NO CONNECTION	17	U	NO CONNECTION
NO CONNECTION	18	V	NO CONNECTION
DATA TRANSMIT	19	W	CH 2 OUT +
STATUS OUTPUT CH 2	20	X	CH 2 OUT -
DATA RECEIVE	21	Y	NO CONNECTION
NO CONNECTION	22	Z	NO CONNECTION

E. Interface Software Requirements

(for setting up communication and data collection, configuring binning, logging, travel direction detection, viewing diagnostics, fault monitoring and parameter setting features)

1. The detector unit shall be capable of remote configuration, system diagnostic measurements and real-time data collection. A communication link shall provide remote access to the detector, for reading its configuration, for fault identification and verification, for real-time monitoring and data collection on two channels. The link shall provide optional password protection to change unit configuration settings. Interface software shall display and report current loop inductance measurements, current or last (historical) fault information, and information specific to the last vehicle detected and vehicle counts. Vehicle information shall include vehicle change of inductance, speed, length and time over loop.

2. A Windows™ based interface and data acquisition software program shall be provided to perform these functions via a remote reporting device running under a Windows™ 95 or Windows™ NT 4.0 operating system.

3. The software shall establish and maintain the communication link to a remote reporting device via a field modem or by direct connection to one of the serial ports on the detector.

4. The software shall be organized by application to simplify setup and monitoring of channel activity measurements, traffic counting, long-loop count, logging of vehicle speed and vehicle length, loop to loop travel time, detect durations, binning of count and occupancy, and sensing of vehicle travel direction with directional detection and call duration.

5. The software shall allow selection of PC's communication port and baud rate, and allow selection of English or metric measurements.

   Baud rate options shall be 1200, 2400, 4800, 9600, or 19200 BPS.

   Direct communication shall be via PC's serial port or with telephone modem communications using one of the PC's COM ports.

6. The software shall include a phone book and dialing utility.

7. The interface and data acquisition software shall provide a Read from Device command on the File menu.

   It shall also provide for a unit address to be selected and allow the selection of a "wildcard" address to establish remote communication.

8. The Initial screen shall open with a Settings icon, a Real-Time Vehicle Logging icon and a Traffic Data Binning icon. After communications have been established with a detector, the other icons shall appear. These shall include the Real-Time Activity Monitoring icon, Force ALL Outputs and LEDs icon, a Reset icon and the Scan-Time icon.

9. A Settings window shall be divided into nine tabs to organize the detector settings by functional application.

10. A General tab shall allow selection of the configuration source to be either from EEPROM or switches, the oscillator frequency for the unit, the vehicle count period and channel sensitivity and mode. When the interface software reads settings from a unit, whichever configuration source is currently active shall determine which settings are displayed in boldface type (EEPROM or switch settings).

11. A Communications tab shall provide for the setting of a field modem command string, transmit delay, selection of the communication baud rates on the front and rear ports, for setting a programmable address and to enable a backpanel address. There shall be provisions to establish, cancel and change a password.

    If password protection is set up in a detector, the unit shall not respond to any requests to perform a reset or change settings until the correct password has been issued. After a verified password has been issued the detector shall respond to all requests for reset or settings changes for 60 minutes. After 60 minutes the unit shall revert back to password protected mode until the password has been issued.

12. Reset shall cause immediate reinstatement of password protection. Most setting changes initiate a reset.

13. A Timing tab shall provide for setting the Delay or Extend Time options and the timing increments for each channel. There shall be an option to select “Enable” Green gating to condition the timing functions to green inputs.

14. A Microloop tab shall provide for selecting microloop mode of operation and setting some of the parameters that are unique to the performance of microloop sensors in special applications.

15. A Long-loop tab shall provide for selecting the option to count vehicles over long loops set to operate in Presence mode. Setup options shall be included to allow for calibrating the algorithm to improve count accuracy on loops of from 20 feet long to 60 feet long. Vehicle counts shall be available over the serial communication ports.

16. A Directional tab shall provide the option of setting up travel direction sensing on channel pairs 1 & 2. With the paired channels connected to 6-foot by 6-foot loops that are overlapped by three feet, vehicles shall be counted in both directions. The directional detection call output shall be assigned to the last loop a vehicle crosses when traveling in the direction that is to be detected. Call Duration shall be selectable for the directional output on the trailing channel of the paired sets.

17. An Output tab shall provide for the option to enable the Status Output for NEMA TS2 Type controllers. Software provision shall also exist to disable the "fail-safe" Call Output for unique system sampling applications.

18. A Noise Immunity tab shall provide for selecting several noise options including a power line filter which can be enabled.

19. An Adapt tab shall provide for selecting the adaptation parameters for the detector unit, to modify default operation.

20. A Real-Time Vehicle Logging icon shall provide for setting up channels to perform vehicle speed and length measurements.

    Facilities shall be provided to insert a loop description (ID label), a loop type (configuration) and a calibration utility to select effective magnetic field loop sizes to improve measurement accuracy. The utility shall also provide for setting up loop assignments and leading edge distances from loop to loop to calculate vehicle speeds. This information shall be saved in the detector's EEPROM.

    Facilities shall be included to activate and view the log with channel IDs, the loop descriptions, dates, times, speeds, lengths, durations, loop to loop times displayed in real-time. Provisions shall be made to save the log to a file and print the log.

21. Traffic Data Binning icon shall open a window to setup and collect binned count and occupancy data from the detector.

    A tab shall provide for setting up the channels to be binned, the start date and time, the end date and time, and the binning intervals.

    The software shall inform the user when the detector will run out of memory based on the setup information provided. If continuous binning is selected the data shall "wrap-around" so that the oldest data will be overwritten with the latest entries.

22. A Real-Time Activity window shall be provided to display all current detection information pertaining to each channel, including current measurements, last fault (or historical fault) information, plus information specific to the last vehicle detected and traffic counts.

    Measurements shall include: loop inductance, loop frequency, reference frequency, green input state and loop status.

    Last Fault shall include fault type, time and date.

    Last Vehicle data shall include Delta L in nanohenries, detect duration, detect time, and detect date.

    Count shall display total count or directional count and the count period remaining.

23. The Activity window shall include a freeze capability to capture the current activity information and hold it for analysis while the software continues to display the most recent changes.

24. A utility window shall be included to verify the operation of a detector's outputs and LEDs and confirm the wiring of a control cabinet to issue the call output to a device or controller. This utility shall allow selection of specific Detect LEDs, Call Outputs, Fault LEDs, and channel Status Outputs to be "forced" ON or OFF for testing the system.

25. A utility window shall be included to remotely reset a detector. It shall be possible to select specific channels, all channels or the entire unit.

26. A utility window shall be included to provide a real-time view of the detector's self-measured scan-time. This interactive utility shall continuously read and display the detector's scan-time and display the theoretical detection performance based on user-selectable parameters such as loop to loop spacing, effective field lengths, channel sensitivity settings, and the effects of any noise immunity options selected.

27. The software shall allow printing of settings, activity measurements, and binned and logged vehicle data.

28. A comprehensive ON-LINE Help utility shall be included with detailed descriptions of unit features and setup information. The Help text shall include hyperlinks to all subjects related to applications or setup sequences. Help screens shall include a print function to print the page.

PART 3 EXECUTION

3.01 LOOP DETECTOR INSTALLATION

A. Each loop and its lead-in wires shall be separate and independent from any others. A minimum of twelve (12) inches shall be maintained between adjacent, parallel sawcuts. The Contractor shall be responsible for a good mechanical and electrical installation of the loop itself and the two lead-wires to and through the curb to the adjacent pull box or hand-hole. This responsibility shall remain with the Contractor until such time as the City can hook up, tune and test the loop for satisfactory operation.

B. Saw Cut: The sawed slot shall be 3/8 inch in width and a minimum of 2 inches in depth for concrete and asphalt. Sawcut shall be deep enough to provide one full inch of sealant above the installed loop wire(s). A sawed slot(s) must be continued from the nearest side or corner of the loop to the conduit thru the curb for the twisted lead-in wires to the adjacent pull box or junction point. The slots shall be brushed and cleared of any debris. Dry moisture-free compressed air shall be used to clear away the remaining dirt, dust and moisture. A one inch hole shall be drilled at each corner to eliminate sharp bends and damage to wire. Contractor shall remove sharp corner as illustrated on detail 3900-08 . Sawcuts shall overlap a sufficient distance to provide continuous full depth of the sawcut. There shall be no angle cuts for corners.

It is the City's desire that loops are not installed across pavement joints. If a proposed loop would cross an existing pavement joint, the Contractor shall request confirmation from the Engineer. With prior approval from the Engineer, City shall pay for additional sawcut to divide the proposed detection area into separate loops which cover the same effective area without crossing pavement joints.

C. The number of turns of loop wire shall be as shown on the drawings, or as follows:

Loop Perimeter, feet	Number of Turns
< 20 feet	4
<= 30 feet	3
> 30 feet	2

D. Positioning Wire: One continuous, unbroken, and unspliced length of wire shall be used to form the loop and its lead-in wires. This wire shall be of sufficient length for the required number of turns plus the distance to the adjacent pull box. The lead-in portion (pair of wires forming ends of loop) shall be twisted a minimum of five (5) turns per linear foot before insertion into slot. The twisted turns shall continue through the conduit at the curb and on to the pull box. Use a blunt tool to push wires into slot. The wires shall be held in place with rubber wedges or sections of insulation.

The sawcut, and loop wire installation shall be inspected by the City's Inspector prior to placement of sealant. Failure to obtain inspection prior to placement of sealant will be reason to require the Contractor to completely reinstall the loop.

E. Sealing: Before and after sealing wires in roadway, test the pair of wires at the pull box for continuity and resistance with an ohm meter. In addition, the integrity of the insulation shall be checked by applying a megger between each end of the loop lead-in and the nearest reliable electrical ground (e.g., street light, hydrant, etc.). In the event that no available ground exists, a suitable ground shall be established for the measurement (e.g., driven metal spike). A resistance of less than ten (10) megohms to ground indicates a faulty installation and must be corrected. Final readings on each detector shall be given to the Inspector or Engineer on the job.

F. Sealer: Use embedding sealer as per manufacturer's instruction or as directed by Engineer. Loop sealant shall be allowed to cure for a minimum of three (3) hours prior to opening the lane for traffic.

G. Conduit: Wires from curb to pull box must be enclosed in conduit as indicated on plan set (1 in. min.) and twisted a minimum of five (5) turns per foot. The conduit shall be rigid in place.

END OF SECTION

SECTION 16731

MODEL 2070 CONTROLLER UNIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification defines the minimum detailed requirements applicable to the Type 2070 Advanced Transportation Controller (ATC) unit. The Advanced Transportation controller (ATC) is a general purpose programmable controller that is intended for continuous unattended operation in harsh environments.

B. This specification defines specific, interchangeable modules that are combined to form a Type 2070 ATC that is capable of running control software that might be provided from a variety of providers. This specification defines several module options that can be arranged in a variety of composition configurations to meet the needs of the user.

C. The Type 2070 version of the ATC is designed such that all components are fully standardized and are therefore interchangeable.

1.02 UNIT PRICES

A. Measurement: This Item will be measured as each traffic signal controller unit furnished, or furnished and installed complete and in place.

B. Payment: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" as each specified controller unit furnished or furnished and installed, and made fully functional and operational and tested in accordance with the requirements in this specification.

1.03 WARRANTY

A. All materials furnished will be warranted by the supplier for a period of two (2) years from date of delivery.

1.04 CONTROLLER DESCRIPTIONS

A. Controller Housing. The Type 2070 controller defines a controller housing that is intended to fit an EIA 19 in. rack mounted form commonly found in the Type 332 and ITS family of cabinets. A NEMA base module is defined for those NEMA TS1 and TS2 shelf mounted applications.

B. CPU Module. The CPU module consists of the main CPU, memory, software and interfaces to the remainder of the controller. The Type 2070-1C configuration is intended to interface with the "engine board" specified by the ATC v5.2 standard.

C. Field I/O Module. The Field I/O Module provides a mechanism for input and output interfaces. The Type 2070-2A Modules are intended to provide a parallel I/O interface with the Type 332 family of cabinets using the C1S and C11S connectors, and a serial I/O interface to the ITS cabinet family. The Type 2070-2B Module is intended to provide a serial I/O interface to the NEMA interface to TS1 cabinets (2070LN).

D. Front Panel Module. A controller Front Panel usually contains a keyboard and display that comprise the user field interface. The Type 2070-3B Front Panel includes a small character (8 lines of 40 characters) LCD.

E. Power Supply Module. A power supply module is used to convert 120 volt power to voltages required to operate the electronics inside the Type 2070 controller unit. This power supply must meet certain minimum electrical characteristics defined herein for its intended use. The Type 2070-4B identifies a 3.5 ampere power supply. Power cord to be supplied with the module should have a minimum length of 4 feet.

F. Communications Module. The Type 2070-7 series of modules are for serial communications.

G. NEMA Interface. This standard includes requirements for an optional module to interface with the NEMA TS1 cabinets. The Type 2070-8 NEMA Field I/O Module is an external module that attaches to the bottom of the 2070 and provides for the typical "A", "B", "C" and "D" NEMA connectors.

1.05 CONTROLLER REQUIREMENTS

A. General. All furnished equipment must be new and unused. Vacuum or gaseous tubes and electro-mechanical devices (unless specifically called out) must not be used.

B. Controller Configurations are specified in section 2.07.

1.06 DOCUMENTATION

A. Manuals: A manual for each piece of equipment shall be provided to the City of Houston upon request in PDF format. The City of Houston reserves the right to make copies of these manuals for internal use only. A minimum of Times New Roman or Arial 10 point font must be used for all manual text, excluding drawings and schematics. Drawing text may use a smaller font size.

1. Manual Contents. Each manual must include the following sections in the order listed:

a. Table of Contents

b. Glossary

c. Manufacturer Contact Information:

(1) Address

(2) Telephone Number

(3) Fax Number

(4) General Email Address

d. General Description

e. General Characteristics

f. Installation

g. Adjustments

h. Theory of Operation:

(1) Systems Description (include block diagram)

(2) Detailed Description of Circuit Operation

i. Maintenance:

(1) Preventive Maintenance

(2) Trouble Analysis

(3) Trouble Shooting Sequence Chart

(4) Wave Forms

(5) Voltage Measurements

(6) Alignment Procedures

j. Parts List (include circuit and board designation, part type and class, power rating, component manufacturer, mechanical part manufacturer, data specification sheets for special design components and original manufacturer's part number).

k. Electrical Interconnection Details & Drawings

l. Schematic and Logic Diagram

m. Assembly Drawings and a pictorial diagram showing physical locations and identification of each component or part

n. The date, model numbers and revision numbers of equipment covered by the manuals must be included on the front cover of the manuals

B. Packaging: Each item delivered must be individually packed in its own shipping container. When loose Styrofoam is used for packing the item, the item must be sealed in a plastic bag to prevent direct contact with the Styrofoam.

C. Delivery: Each item delivered for testing must be complete, including manuals, and ready for testing.

D. Metals: All sharp edges and corners must be rounded and free of any burrs.

1. Aluminum. Sheet must be 63 gauge American Standard (0.060-in.) minimum thick Type 3003-H14 or Type 5052-H32 ASTM Designation B209 aluminum alloy. Rod, Bar and Extruded must be Type 6061-T6, or equal.

2. Stainless Steel. Sheet must be annealed or one-quarter-hard complying with the ASTM Designation: A666 for Type 304, Grades A or B, stainless steel sheet.

3. Cold Rolled Steel. Sheet, Rod, Bar and Extruded must be Type 1018/1020.

a. Plating. All cold roll steel must be plated. All plating must be either cadmium plating meeting the requirements of Federal Specification QQ-P-416C, Type 2 Class l or zinc plating meeting the requirements of ASTM B633-85 Type II SC4.

E. Mechanical Hardware. All bolts, nuts, washers, screws, hinges and hinge pins must be stainless steel unless otherwise specified.

F. Electrical Isolation. Within the circuit of any device, module, or Printed Circuit Board (PCB), electrical isolation must be provided between DC logic ground, equipment ground and the AC- conductor. They must be electrically isolated from each other by 500 megohms, minimum, when tested at the input terminals with 500 VDC.

G. Daughter Boards. Keyboards and LCD/LED Displays are considered daughter boards. Daughter boards must be mechanically secured with a minimum of four spacers/metal screws. Connectors must be either Flat Cable or PCB Headers. Components are to be mounted under the daughter board.

PART 2 PRODUCTS

2.01 COMPONENTS

A. General. All components must be second sourced and must be of such design, fabrication, nomenclature or other identification as to be purchased from a wholesale distributor or from the component manufacturer. When a component is of such special design that it precludes the purchase of identical components from any wholesale distributor or component manufacturer, one spare duplicate component

must be furnished with each twenty, or fraction thereof, components used. The electronic circuit design must be such that all components of the same generic type, regardless of manufacturer, must function equally in accordance with the specifications.

B. Electronic Components:

1. No device to be socket mounted unless specifically called out.

2. No component to be operated above 80% of its maximum rated voltage, current or power ratings. Digital components must not be operated above 3% over their nominal voltage, current or power ratings.

3. No component to be provided where the manufactured date is three years older than the contract award date. The design life of all components, operating for twenty- four hours a day and operating in their circuit application, must be ten years or longer.

4. Components must be arranged so they are easily accessible, replaceable and identifiable for testing and maintenance. Where damage by shock or vibration exists, a clamp, fastener, retainer, or hold-down bracket must support the component mechanically.

5. The Manufacturer must submit detailed engineering technical data on all components at the request of the City of Houston. The Manufacturer must certify that the component application meets the requirements of this standard.

C. Capacitors. The DC and AC voltage ratings as well as the dissipation factor of a capacitor must exceed the worst-case design parameters of the circuitry by 150%. Capacitor encasements must be resistant to cracking, peeling and discoloration. All capacitors must be insulated and must be marked with their capacitance values and working voltages. Electrolytic capacitors must not be used for capacitance values of less than 1.0 microfarad and must be marked with polarity.

D. Potentiometers. Potentiometers with ratings from 1 to 2 watts must meet Military Type RV4 requirements. Less than 1 Watt potentiometers must be used only for trimmer type function. The potentiometer power rating must be at least 100% greater than the maximum power requirements of the circuit.

E. Resistors. Fixed carbon film, deposited carbon, or composition-insulated resistors must conform to the performance requirements of Military Specifications MIL-R-11F or MIL-R-22684. All resistors must be insulated and be marked with their resistance values. Resistance values must be indicated by the EIA color codes, or stamped value. The value of the resistors must not vary by more than 5% between -37 degrees C and 74 degrees C.

1. Special ventilation or heat sinking must be provided for all 2- watt or greater resistors. They must be insulated from the PCB.

F. Semiconductor Devices:

1. All transistors, integrated circuits, and diodes must be a standard type listed by EIA and clearly identifiable.

2. All metal oxide semiconductor components must contain circuitry to protect their inputs and outputs against damage due to high static voltages or electrical fields.

3. Device pin "1" locations must be properly marked on the PCB adjacent to the pin.

G. Transformers and Inductors. All power transformers and inductors must have the manufacturer's name or logo and part number clearly and legibly printed on the case or lamination. All transformers and inductors must have their windings insulated, be protected to exclude moisture, and their leads color coded with an approved EIA color code or identified in a manner to facilitate proper installation.

H. Triacs. Each triac with a designed circuit load of greater than 0.5 Amperes at 120 VAC must be mounted to a heat sink with thermal conductive compound or material, in addition to being mechanically secured.

I. Circuit Breakers. Circuit breakers must be listed by UL or ETL. The trip and frame sizes must be plainly marked (marked on the breaker by the manufacturer), and the ampere rating visible from the front of the breaker. Contacts must be silver alloy and enclosed in an arc-quenching chamber. An ambient air temperature range of from -18 degrees C to 50 degrees C must not influence overload tripping. The minimum Interrupting Capacity must be 5,000 amperes, RMS when the breaker is secondary to a UL approved fuse or primary circuit breaker and both breakers in concert provide the rated capacity. For circuit breakers 80 amperes and above, the minimum interrupting capacity must be 10,000 amperes, RMS. Circuit breakers must be the trip-free type with medium trip delay characteristic (Carlingswitch Time Delay Curve #24 or equal).

1. Load Circuit Breaker Auxiliary Internal Switches. The Load Circuit Breakers used to power Switch Packs must have auxiliary switches. The auxiliary switches must "open" when the load breaker has tripped and the system will transfer the power from the Main Contactor to the Flash or Blank condition.

J. Fuses. All Fuses that are resident in a bayonet style fuse holder must have the fuse size rating labeled on the holder or on the panel adjacent to the holder. Fuses must be easily accessible and removable without use of tools.

K. Switches:

1. Dip. Dual-inline-package, quick snap switches must be rated for a minimum of 30,000 operations per position at 50 milliamperes, 30 VDC. The switch contact

resistance must be 100 milliohms maximum at 2 milliamperes, 30 VDC. The contacts must be gold over brass.

2. Logic. The switch contacts must be rated for a minimum of 1-ampere resistive load at 120 VAC and must be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

3. Control. The switch contacts must be rated for a minimum of 5 amperes resistive load at 120 VAC or 28 VDC and be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

4. Power. Ratings must be the same as CONTROL, except the contact rating must be a minimum of 10 amperes at 125 VAC.

L. Terminal Blocks. The terminal blocks must be barrier type, rated at 20 amperes and 600 VAC RMS minimum. The terminal screws must be 0.3125 in. minimum length nickel- plated brass binder head type with screw inserts of the same material. Screw size is called out under the associated file, panel or assembly.

M. Screw Lug and Cam Driven Connectors. Provided the connectors mate, screw lug cam driven devices or crimp pin connectors must be allowable if the interface is part of a harness. For field termination, screw lug and cam driven assemblies are interchangeable for field wiring termination, provided they both accommodate 22-gauge wire on the inputs and 22-gauge wire on the outputs.

N. Wiring, Cabling and Harnesses:

1. Harnesses must be neat, firm and properly bundled with external protection. They must be tie-wrapped and routed to minimize crosstalk and electrical interference. Each harness must be of adequate length to allow any conductor to be connected properly to its associated connector or termination point. Conductors within an encased harness have no color requirements. Printed circuit motherboards are to be used where possible to eliminate or reduce cabinet wiring.

2. Wiring containing AC must be bundled separately or shielded separately from all DC logic voltage control circuits.

3. Wiring must be routed to prevent conductors from being in contact with metal edges. Wiring must be arranged so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

4. All conductors, except those that can be readily traced, must be labeled. Labels attached to each end of the conductor must identify the destination of the other end of the conductor.

5. All conductors must conform to MIL-W-16878E/1 or better and have a minimum of 19 strands of copper. The insulation must be polyvinyl chloride

with a minimum thickness of 10 mils or greater. Where insulation thickness is 15 mils or less, the conductor must conform to MIL-W-16878/17.

6. Conductor color identification must be as follows:

   a. AC- circuits - white

   b. Equip. Ground - solid green or continuous green color with 1 or more yellow stripes

   c. DC logic ground - continuous white with a red stripe

   d. AC+ circuits - continuous black or black with colored stripe

   e. DC logic ungrounded or signal - any color not specified

O. Indicators and Character Displays:

1. All indicators and character displays must be readily visible at a radius of up to 4 feet within the cone of visibility when the indicator is subjected to 97,000 lux (9,000 foot-candles) of white light with the light source at 45 degrees (+/-2 degrees) to the front panel.

2. All indicators and character displays must have a minimum 90 degrees cone of visibility with its axis perpendicular to the panel on which the indicator is mounted. All indicators must be self-luminous. All indicators must have a rated life of 100,000 hours minimum. Each LED indicator must be white or clear when off. Indicators supplied on equipment requiring handles must be mounted such that a horizontal clearance is provided.

3. Liquid Crystal Displays (LCD) must be readable at temperatures of -20 degrees C to +70 degrees C. All controller unit functions are required to operate at temperatures of -37 degrees C to +74 degrees C.

P. Connectors. Connectors must be keyed to prevent improper insertion of the wrong connector where equipment damage or operator injury may result. The mating connectors must be designated as the connector number and male/female relationship, such as C1P (plug or PCB edge connector) and C1S (socket).

1. Type T. Type T connector must be a single row, 10 position, feed through terminal block. The terminal block must be a barrier type with 6-32, 0.25 in. or longer, nickel plated brass binder head screws. Each terminal must be permanently identified as to its function.

2. Plastic Circular and Type M. Pin and socket contacts for connectors must be beryllium copper construction subplated with 1.27 microns nickel and plated with 0.76 microns gold. Pin diameter must be 0.0618 in. All pin and socket

connectors must use the AMP #601105-1 or #91002-1 contact insertion tool and the AMP #305183 contact extraction tool or equal.

3. Card Edge and Two Piece PCB:

   a. Edge connectors must have bifurcated gold-plated contacts. The PCB receptacle connector must meet or exceed the following:

      (1) Operating Voltage: 600 VAC (RMS)

      (2) Current Rating: 5.0 Amperes

      (3) Insulation Material: Diallyl Phthalate or Thermoplastic

      (4) Insulation Resistance: 5,000 Megohms

      (5) Contact Material: Copper alloy plated with 0.00005 in. of nickel and 0.000015 in. of gold

      (6) Contact Resistance: 0.006 Ohm maximum

   b. The two-piece PCB connector must meet or exceed the DIN 41612.

   c. The PCB 22/44 Connector must have 22 independent contacts per side; dual sided with 0.156 in. contact centers.

4. Wire Terminal. Each wire terminal must be solderless with PVC insulation and a heavy-duty short -locking spade type connector. Crimp terminal connectors using a Controlled-Cycle type crimping tool.

5. Flat Cable. Each flat cable connector must be designed for use with 26 AWG cable; have dual cantilevered phosphor bronze contacts plated with 0.00015 in. of gold over 0.00005 in. of nickel; and have a current rating of 1 Ampere minimum and an insulation resistance of 5 Megohms minimum.

6. PCB Header Post. Each PCB header post must be 0.025 in. square by 0.3425 in. high from the plane of the PCB to the end of the pin; be mounted on 0.10 in. centers; and be tempered hard brass plated with 0.00015 in. of gold over 0.00005 in. of nickel.

7. PCB Header Socket. Each PCB header socket block must be nylon or diallyl phthalate. Each PCB header socket contact must be removable, but crimp-connected to its conductor. List the part number of the extraction tool recommended by its manufacturer. Each PCB header socket contact must be brass or phosphor bronze plated with 0.0015 in. of gold over 0.00005 in. of nickel.

Q. Surge Protection Device. The surge suppression device must comply with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds - 8/20

Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit).

2.02 MECHANICAL REQUIREMENTS

A. Assemblies. All assemblies must be modular, easily replaceable and incorporate plug-in capability for their associated devices or PCBs. Assemblies must be provided with two guides for each plug-in PCB or associated device (except relays). The guides must extend to within 0.75 in. from the face of either the socket or connector and front edge of the assembly. If Nylon guides are used, attach the guides securely to the file or assembly chassis.

B. Locking Devices. All screw type fasteners must utilize locking devices or locking compounds except finger screws, which are captive.

C. PCB Design and Connectors. No components, traces, brackets or obstructions are to be within 0.125 in. of the board edge (guide edges). The manufacturer's name or logo, model number, serial number, and circuit issue or revision number must appear and be readily visible on all PCBs.

D. Model and Serial Numbers:

1. The manufacturer's model number, and circuit issue or revision number must appear on the rear panel of all equipment supplied (where such panel exists). In addition to any assignment of model numbers by the manufacturer, the TYPE number must be displayed on the front panel in bold type, at least 0.25 in. high.

2. A permanent label must be affixed to the inside near and center floor of the Type 2070 unit chassis when viewed from the front. The label must display the unit's serial number and be permanent and easy to read.

3. Workmanship. Workmanship must conform to the requirements of this specification and be in accordance with the highest industry standards.

4. Tolerances. The following tolerances must apply, except as specifically shown on the plans or in these specifications:

a. Sheet Metal +/-0.0525 in.

b. PCB +0 in., - 0.010 in.

c. Edge Guides +/-0.015 in.

d. Note: These dimensional tolerances do not apply to material gauge or thickness

2.03 ENGINEERING

A. Human Engineering. The equipment must be engineered for simplicity, ease of operation and maintenance.

1. Knobs must be a minimum of 0.5 in. in diameter and a minimum separation of 0.5 in. edge to edge.

2. PCBs must slide smoothly in their guides while being inserted into or removed from the frame and fit snugly into the plug-in PCB connectors. PCBs must require a force no less than 5 pounds-force or greater than 50 pounds-force for insertion or removal.

B. Design Engineering. The design must be inherently temperature compensated to prevent abnormal operation. The circuit design must include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range. The design must take into consideration the protection of personnel from all dangerous voltages.

C. Generated Noise. No item, component or subassembly is to emit an audible noise level exceeding the peak level of 55 dBa when measured at a distance of one meter away from its surface, except as otherwise noted. No item, component or subassembly is to emit a noise level sufficient to interfere with processing and communication functions of the controller circuits.

2.04 PRINTED CIRCUIT BOARDS

A. Design, Fabrication and Mounting:

1. All contacts on PCBs must be plated with a minimum thickness of 0.00003 in. gold over a minimum thickness of 0.000075 in. nickel.

2. PCB design must be such that when a component is removed and replaced, no damage is done to the board, other components, conductive traces or tracks.

3. Fabrication of PCBs must be in compliance with Military Specification MIL-P-13949, except as follows:

a. NEMA FR-4 glass cloth base epoxy resin copper clad laminates 0.0625 in. minimum thickness must be used. Inter-component wiring must be by laminated copper clad track having a minimum weight of 0.2 ounces per square foot with adequate cross section for current to be carried. All copper tracks must be plated or soldered to provide complete coverage of all exposed copper tracks. Jumper wires to external PCB components must be from plated- through padded holes and as short as possible.

b. All PCBs must conform to Section 3.3 of Military Specification MIL-P-13949G Grade of Pits and Dents and be of Grade B quality (3.5.1.3) or better. The class of permissible bow or twist must be Class C (Table V) or

better. The class of permissible warp or twist must be Class A (Table II) or better.

c. Omit Sections 4.2 through 6.6 of Military Specification MIL-P-13949G (inclusive) except as referenced in previous sections of this specification.

d. The mounting of parts and assemblies on the PCB must conform to Military Specification MIL-STD-275E, except as follows:

(1) Semiconductor devices that dissipate more than 250 milliwatts or cause a temperature rise of 10 degrees C or more must be mounted with spacers, transipads or heat sinks to prevent contact with the PCB.

(2) When completed, remove all residual flux from the PCB.

(3) The resistance between any two isolated, independent conductor paths must be at least 100 Megohms when a 500 VDC potential is applied.

(4) All PCBs must be coated with a moisture resistant coating.

(5) Where less than 0.25 in. lateral separation is provided between the PCB (or the components of a PCB) and any metal surface, a 0.0625 in. (+/- 0.0005 in.) Thick Mylar (polyester) plastic cover must be provided on the metal to protect the PCB.

e. Each PCB connector edge must be chamfered at 30 degrees from boardside planes. The key slots must also be chamfered so that the connector keys are not extracted upon removal of board or jammed upon insertion. The key slots must be 0.045 in. (+/-0.005 in.) for 0.1 in. spacing and 0.055 in. (+/- 0.005 in.) for 0.156 in. spacing.

B. Soldering:

1. Hand soldering must comply with J-STD-001.

2. Automatic flow soldering must be a constant speed conveyor system with the conveyor speed set at optimum to minimize solder peaks or points. Temperature must be controlled to within +/- 8 degrees C of the optimum temperature. The soldering process must result in the complete coverage of all copper runs, joints and terminals with solder except that which is covered by an electroplating process. Wherever clinching is not used, provide a method of holding the components in the proper position for the flow process.

3. If exposure to the temperature bath is of such a time-temperature duration, as to come within 80% of any component's maximum specified time-temperature exposure, that component must be hand soldered to the PCB after the flow process has been completed.

C. Definitions. Definitions for the purpose of this section on PCBs must be taken from MIL-P-55110D Section 3.3 and any current addendum.

D. Jumpers. Jumpers are not allowed unless called out in the specifications or approved by the City of Houston.

2.05 QUALITY CONTROL

A. Components. All components must be lot sampled to assure a consistent high conformance standard to the design specification of the equipment.

B. Subassembly, Unit or Module. Complete electrical, environmental and timing compliance testing must be performed on each module, unit, printed circuit or subassembly. Components will be tested as a complete controller assembly. Housing, chassis, and connection terminals must be inspected for mechanical sturdiness, and harnessing to sockets to be electrically tested for proper wiring sequence. The equipment must be visually and physically inspected to assure proper placement, mounting, and compatibility of subassemblies.

C. Pre-delivery Repair:

1. Any defects or deficiencies found by the inspection system involving mechanical structure or wiring must be returned through the manufacturing process or special repair process for correction.

2. PCB flow soldering is allowed a second time if copper runs and joints are not satisfactorily coated on the first run. Do not flow solder a PCB more than twice.

3. Hand soldering is allowed for printed circuit repair.

2.06 ELECTRICAL, ENVIRONMENTAL AND TESTING REQUIREMENTS

A. The framework of this section, along with the specific test requirements contained herein, is excerpted with modifications from NEMA TS2-2003 - Section 2 by permission of NEMA. Excerpt © 2002 AASHTO / ITE / NEMA. . In the case where these requirements differ from the testing requirements in ATC Standard 5.2b, then apply ATC Standard 5.2b requirements ONLY to 1C modules.

B. General. This section establishes the limits of the environmental and operational conditions in which the Controller Assembly will perform. This section defines the minimum test procedures that may be used to demonstrate conformance of a device type with the provisions of the standard. These test procedures do not verify equipment performance under every possible combination of environmental requirements covered by this standard. Nothing in this testing profile must be construed as to relieve the requirement that the equipment provided must fully comply with these standards/specifications under all environmental conditions stated herein. The City of Houston may wish to extend the testing profile or introduce additional tests to verify compliance. (Authorized Engineering Information).

C. Inspection. A visual and physical inspection must include mechanical, dimensional and assembly conformance to all parts of this standard.

D. Testing Certification.

1. A complete quality control / final test report must be supplied with each item. Quality control procedures must be submitted to the City of Houston prior to production. The test report must indicate the name of the tester and be signed by a responsible manager.

2. The quality control procedure and test report format must be supplied to the City of Houston for approval upon request. The quality control procedure must include the following, in the order shown:

a. Design Acceptance testing of all supplied components.

b. Physical and functional testing of all modules and items.

c. Environmental testing reports for all equipment.

d. Physical and functional testing of all items.

3. Separate certifications must be provided for Design and Production. Design Acceptance testing must be performed with a fully loaded and functional Cabinet Assembly. Production testing must be performed as part of the City of Houston's procurement delivery procedures and that testing should be performed at the Major Unit level. (Authorized Engineering Information)

4. Certain portions of the test procedures contained in this standard my cause damage to the unit (e.g. protection devices may be aged) and are not recommended for routine Production testing. (Authorized Engineering Information)

E. Definitions of Major Units of the Cabinet Assembly. For the purpose of this section, "Major units of the Cabinet Assembly" must include the Controller Unit, Application Software for implementing the desired functionality, Cabinet Monitor Unit (CMU), Auxiliary Monitor Unit (AMU), Serial Interface Units (SIUs), Power Distribution Unit (PDA), Switch Packs, Flasher(s), and Detector(s).

F. Environmental and Operating Requirements. The requirements (voltage, temperature, etc.) of this section must apply in any combination.

1. Voltage and Frequency.

a. Operating Voltage. The nominal voltage must be 120 VAC, unless otherwise noted.

b. Operating Frequency. The operating frequency range must be 60 hertz (+/- 3.0 hertz), unless otherwise noted.

2. Transients, Power Service. The Test Unit must maintain all defined functions when the independent test pulse levels specified below occur on the alternating-current power service.

   a. High Repetition Noise Transients

      (1) The test pulses must not exceed the following conditions:

         (a) Amplitude: 300 Volts, both positive and negative polarity.

         (b) Peak Power: 2500 watts.

         (c) Repetition: 1 pulse approximately every other cyclemoving uniformly over the full wave in order to sweep across 360 degrees of the line cycle once every 3 seconds.

         (d) Pulse Rise Time: 1 microsecond.

         (e) Pulse Width: 10 microseconds.

         (f) This test is performed without protection in place or operational.

         (g) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

   b. Low Repetition High Energy Transients.

      (1) The test pulses must not exceed the following conditions:

         (a) Amplitude: 600 Volts (+/-5 percent), both positive and negative polarity.

         (b) Energy Source: Capacitor, oil filled, 10 microfarads (+/-10 percent), internal surge impedance less than 1 ohm.

         (c) Repetition: 1 discharge every 10 seconds.

         (d) Pulse Position: Random across 360 degrees of the line cycle.

         (e) This test is performed with protection in place and operational. This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

   c. Nondestructive Transient Immunity.

(1) The Test Unit (with protection in place and operational) must be capable of withstanding a high energy transient having the following characteristics repeatedly applied to the alternating current input terminals (no other power connected to terminals) without failure of the test specimen:

(a) Amplitude: 1000 Volts (+/-5 percent), both positive and negative polarity.

(b) Energy Source: Capacitor, oil filled, 15 microfarads (+/-10 percent), internal surge impedance less than 1 ohm.

(c) Repetition: Applied to the Test Unit once every 2 seconds for a maximum of three applications for each polarity.

(d) After the foregoing, the Test Unit must perform all defined functions upon the application of nominal alternating current power.

(e) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds - 8/20 Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit). Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

d. Transients, Input-Output Terminals.

(1) The Test Unit (without protection in place or operational) must maintain all defined functions, when the test pulse occurs on the input-output terminals.

(a) Amplitude: 300 Volts, both positive and negative polarity.

(b) Pulse Source: 1000 ohms nominal impedance.

(c) Repetition: 1 pulse per second, for a minimum of 5 pulses per selected terminal.

(d) Pulse rise time: 1 microsecond.

(e) Pulse width: 10 microseconds.

(f) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional

conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

e. Temperature and Humidity. The Test Unit must maintain all programmed functions when the temperature and humidity ambients are within the specified limits defined herein.

(1) Ambient Temperature.

(a) The operating ambient temperature range must be from -37 degrees C to +74 degrees C. The storage temperature range must be from -45 degrees C to +85 degrees C.

(b) The rate of change in ambient temperature must not exceed 18 degrees C per hour, during which the relative humidity must not exceed 95 percent.

(2) Humidity.

(a) The relative humidity must not exceed 95 percent non-condensing over the temperature range of -37 degrees C to +74 degrees C.

(b) Above +46 degrees C, constant absolute humidity must be maintained. This will result in the relative humidity shown in Table 1 for dynamic testing.

Table 1
AMBIENT TEMPERATURE VERSUS RELATIVE HUMIDITY
AT BAROMETRIC PRESSURES (29.92 In. Hg.) (NON-CONDENSING)

Ambient Temperature/ Dry Bulb (in degrees C)	Relative Humidity (in percent)	Ambient Temperature/ Wet Bulb (in degrees C)
-37.0 to 1.1	10	-17.2 to 42.7
1.1 to 46.0	95	42.7
48.8	70	42.7
54.4	50	42.7
60.0	38	42.7
65.4	28	42.7
71.2	21	42.7
74.0	18	42.7

f. Test Facilities. All instrumentation required in the test procedures, such as voltmeters, ammeters, thermocouples, pulse timers, etc. must be selected in accordance with good engineering practice. In all cases where time limit tests are required, the allowance for any instrumentation errors must be included in the limit test.

(1) Variable Voltage Source: A variable source capable of supplying 20 amperes from 100 VAC to 135 VAC.

(2) Environmental Chamber: An environmental chamber capable of

attaining temperatures of -37 degrees C to +74 degrees C and relative humidity given in Table 1.

(3) Transient Generators: Transient generators capable of supplying the transients outlined above.

G. Test Procedure: Transients, Temperature, Voltage, and Humidity

1. Test A: Placement in Environmental Chamber and Check-Out of Hook-Up

a. Place the test unit in the environmental chamber. Connect the test unit AC input circuit to a variable voltage power transformer, voltmeter, and transient generator. The transient generator must be connected to the AC input circuit at a point at least 25 feet from the AC power source and not over 10 feet from the input to the test unit.

b. Connect test switches to the appropriate terminals to simulate the various features incorporated into the test unit. Place these switches in the proper position for desired operation.

c. Verify the test hook-up. Adjust the variable-voltage power transformer to 120 VAC and apply power to the test unit. Verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the operation determined by the positioning of test switches in item b.

d. Upon the satisfactory completion and verification of the test hook-up, proceed with Test B.

2. Test B: Transient Tests (Power Service)

a. Program the test unit to dwell. Verify the input voltage is 120 VAC.

b. Set the transient generator to provide high-repetition noise transients as follows:

(1) Amplitude: 300 Volts (+/-5 percent), both positive and negative polarity.

(2) Peak Power: 2500 watts.

(3) Repetition Rate: One pulse every other cycle moving uniformly over the full wave in order to sweep once every 3 seconds across 360 degrees of line cycle.

(4) Pulse Rise Time: 1 microsecond.

(5) Pulse Width: 10 microseconds.

c. Apply the transient generator output to the AC voltage input for at least 5 minutes. Repeat this test for at least two conditions of dwell for the test unit. The test unit must continue to dwell without malfunction.

d. Program the test unit to cycle through normal operations. Turn on the transient generator (output in accordance with item 2) for 10 minutes, during which time the test unit must continue to cycle without malfunction.

e. Set a transient generator to provide high-repetition noise transients as follows:

(1) Amplitude: 300 Volts (+/-5 percent), both positive and negative polarity.

(2) Source Impedance: Not less than 1000 ohms nominal impedance.

(3) Repetition: One pulse per second for a minimum of five pulses per selected terminal.

(4) Pulse Rise Time: 1 microsecond.

(5) Pulse Width: 10 microseconds.

(6) Program the test unit to dwell. Verify the input voltage is 120 VAC.

f. Apply the transient generator (output in accordance with item 5) between logic ground and the connecting cable termination of selected Field I/O input/output terminals of the test unit. A representative sampling of selected input/output terminations must be tested. The test unit must continue to dwell without malfunction.

g. Program the test unit to cycle. Turn on the transient generator (output in accordance with item 5) and apply its output to the selected Field I/O input/output terminations. The test unit must continue to cycle without malfunction.

h. Reinstall protection and set a transient generator to provide low-repetition high-energy transients as follows:

(1) Amplitude: 600 Volts (+/-5 percent), both positive and negative polarity.

(2) Energy Discharge Source: Capacitor, oil-filled, 10 microfarads.

(3) Repetition Rate: One discharge each 10 seconds.

(4) Pulse Position: Random across 360 degrees of line cycle.

i. Program the test unit to dwell. Verify the input voltage is 120 VAC.

j. Discharge the oil-filled 10-microfarad capacitor ten times for each polarity across the AC voltage input. Repeat this test for at least two conditions of dwell. The test unit must continue to dwell without malfunction.

k. Program the test unit to cycle through normal operations. Discharge the

capacitor ten times for each polarity while the test unit is cycling, during which time the test unit must continue to cycle without malfunction.

l. During the preceding transient tests, the test unit must continue its programmed functions. The test unit must not skip normal program intervals/steps or portions thereof when in normal operation; place false inputs or produce false outputs while in dwell; disrupt normal sequences in any manner; or change parameters.

m. Nondestructive Transient Immunity:

(1) Turn off the AC power input to the test unit from the variable-voltage power source.

(2) Apply the following high-energy transient to the AC voltage input terminals of the test unit (no other power connected to terminals):

(a) Amplitude: 1000 V, both positive and negative polarity.

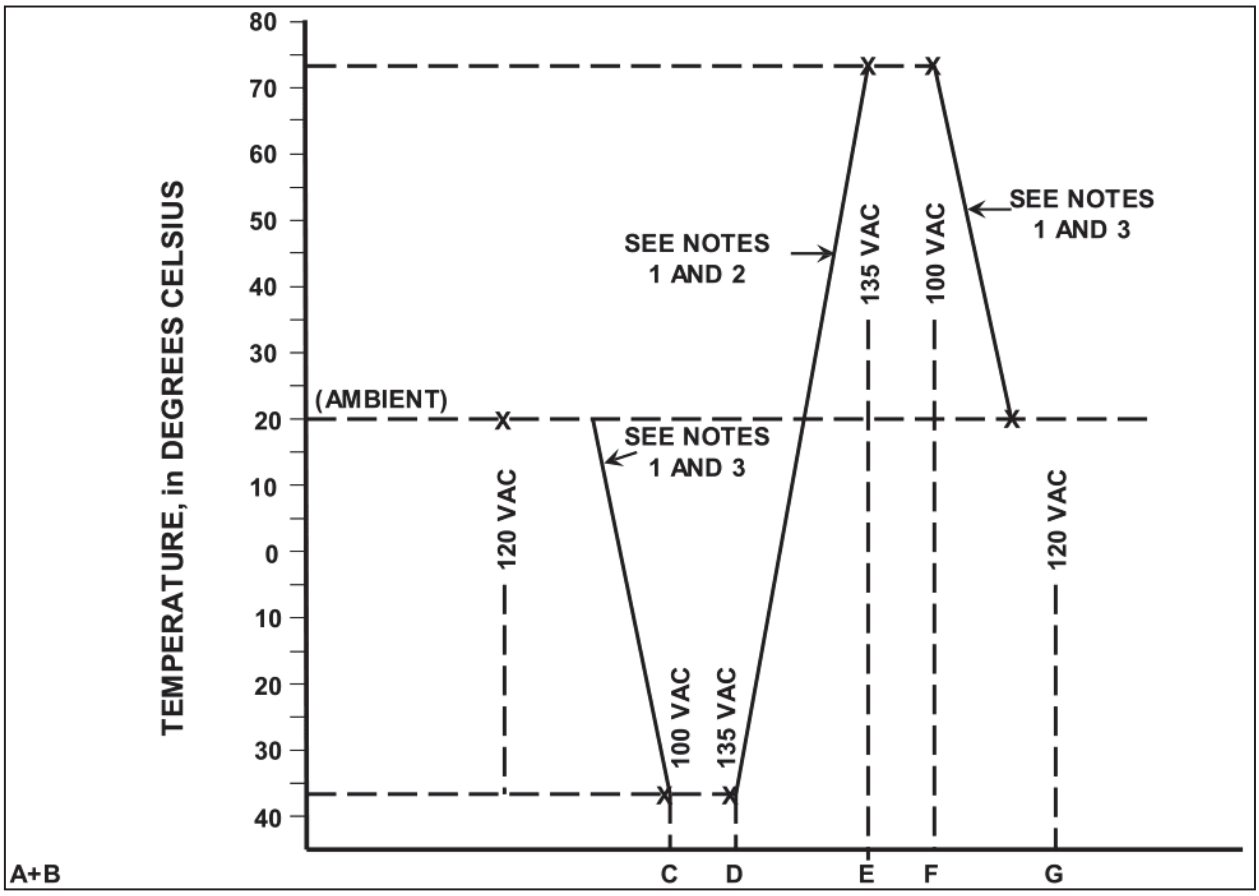
(b) Peak Power Discharge: Capacitor, oil-filled, 15 microfarads.

(c) Maximum Repetition Rate: Applied to the Cabinet Assembly once every 2 seconds for a maximum of three applications for each polarity.

(3) Upon completion of the foregoing, apply 120 VAC to the test unit and verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the programmed functions. The first operation of the over-current protective device during this test is not considered a failure of the test unit.

NOTE—Test C through G follow the profile indicated in Figure 1 to demonstrate the ability of the test unit to function reliably under stated conditions of temperature, voltage, and humidity.

Figure 1
Test Profile



NOTES:

1. The rate of change in temperature must not exceed 18 degrees C per hour.
2. Humidity controls must be set in conformance with the humidity given in Table 1 during the temperature change between Test D and Test E.
3. If a change in both voltage and temperature are required for the next test, the voltage must be selected prior to the temperature change.

n. Test C—Low-Temperature Low-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) Temperature: -37 degrees C.

(c) Low Voltage: 100 VAC.

(d) Humidity Control: Off.

(2) Test Procedure: While at room temperature, adjust the input voltage to 100 VAC and verify that the test unit is still operable.

(a) With the test unit cycling through normal operations, lower the test chamber to -37 degrees C at a rate not exceeding 18 degrees C per hour. Allow the test unit to cycle for a minimum of 5 hours at -37 degrees C with the humidity controls in the off position. Then operate the test switches as necessary to determine that all functions are operable.

(b) Remove power from the test unit for a minimum period of 5 hours. Upon restoration of power, the test unit must go through its prescribed startup sequence and then resume cycling.

(c) With the test unit at -37 degrees C and the input voltage at 100 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(d) On satisfactory completion of this test, proceed with Test D.

o. Test D—Low-Temperature High-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: closed.

(b) Low Temperature: -37 degrees C.

(c) High Voltage: 135 VAC

(d) Humidity Controls: Off.

(2) Test Procedure: While at -37 degrees C and with humidity controls off, adjust the input voltage to 135 VAC and allow the test unit to cycle for 1 hour. Then operate the test switches as necessary to determine that all functions are operable.

(3) With the test unit at -37 degrees C and the input voltage at 135 VAC (humidity controls off), evaluate the following items against the respective Power Interruption Tests standards.

(4) On satisfactory completion of this test, proceed to Test E.

p. Test E—High-Temperature High-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) High Temperature: +74 degrees C.

(c) High Voltage: 135 VAC.

(d) Humidity Controls: In accordance with the humidity given in Table 1.

(2) Test Procedure—With the test unit cycling, raise the test chamber to +74 degrees C at a rate not to exceed 18 degrees C per hour. Verify the input voltage is 135 VAC.

(3) Set the humidity controls to not exceed 95 percent relative humidity over the temperature range of +1.1 degrees C to +46 degrees C. When the temperature reaches +46 degrees C, readjust the humidity control to maintain constant absolute humidity; +42.7 degrees C wet bulb that results in the relative humidity shown in Table 1. Verify that the test unit continues to cycle satisfactory during the period of temperature increase and at established levels of relative humidity.

(a) Allow the test unit to cycle for a minimum of 15 hours at +74 degrees C and 18 percent relative humidity. Then operate the test switches as necessary to determine that all functions are operable.

(b) With the test unit at +74 degrees C and 18 percent relative humidity and the input voltage at 135 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(4) On satisfactory completion of this test, proceed to Test F.

q. Test F—High-Temperature Low-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) High Temperature: +74 degrees C.

(c) Low Voltage: 100 VAC.

(d) Humidity Controls: 18 percent relative humidity and +42.7 degrees C wet bulb.

(e) Test Procedure: Adjust the input voltage to 100 VAC and proceed to operate the test switches to determine that all functions are operable. With the test unit at +74 degrees C and 18 percent relative humidity, +42.7 degrees C wet bulb, and the input voltage at 100 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(f) On satisfactory completion of this test, proceed to Test G.

r. Test G—Test Termination

(1) Program the test unit to cycle.

(2) Adjust the input voltage to 120 VAC.

(3) Set the controls on the environmental chamber to return to room temperature, +20 degrees C (+/-5 degrees C), with the humidity controls in the off position. The rate of temperature change must not exceed 18 degrees C per hour.

(4) Verify the test unit continues to cycle through normal operations properly.

(5) Allow the test unit to stabilize at room temperature for 1 hour. Proceed to operate the test switches to determine that all functions are operable.

s. Test H—Appraisal of Equipment under Test

(1) A failure is defined as any occurrence that results in other than normal operation of the equipment. (See sub-section item b. below for details.) If a failure occurs, the test unit must be repaired or components replaced, and the test during which failure occurred must be restarted from its beginning.

(2) The test unit is considered to have failed if any of the following occur:

(a) If the test unit skips normal program intervals/steps or portions thereof when in normal operation, places false inputs, presents false outputs, exhibits disruption of normal sequence of operations, or produces changes in parameters beyond specified tolerances, or

(b) If the test unit fails to satisfy the requirements of Tests A to G, inclusive.

(3) An analysis of the failure must be performed and corrective action taken before the test unit is retested in accordance with this standard. The analysis must outline what action was taken to preclude additional failures during the tests.

(4) When the number of failures exceeds two, it must be considered that the test unit fails to meet these standards. The test unit may be completely retested after analysis of the failure and necessary repairs have been made in accordance with item (3).

(5) Upon completion of the tests, visually inspect the test unit. If material changes are observed which will adversely affect the life of the test unit, the cause and conditions must be corrected before making further tests.

(6) Upon satisfactory completion of all of the tests described, test the unit in accordance with Vibration Test.

t. Vibration Test.

(1) Purpose of Test. This test is intended to duplicate vibrations encountered by the test unit (individual major components) when installed at its field location.

(a) Fasten the test unit securely to the vibration test table prior to the start of the test.

(2) Test Equipment Requirements.

(a) Vibration table with adequate table surface area to permit placement of the test unit

(b) Vibration test consists of:

I. Vibration in each of three mutually perpendicular planes.

II. Adjustment of frequency of vibration over the range from 5 hertz to 30 hertz.

III. Adjustment of test table excursion (double amplitude displacement) to maintain a 'g' value, measured at the test table, of 0.5g; as determined by the following formula:

$$g = 0.0511df^2$$

where

d = excursion, inches

f = frequency, hertz

(3) Resonant Search

(a) With the test unit securely fastened to the test table, set the test table for a double amplitude displacement of 0.015 inch.

(b) Cycle the test table over a search range from 5 hertz to 30 hertz and back within a period of 12.5 minutes.

(c) Conduct the resonant frequency search in each of the three mutually perpendicular planes.

(d) Note and record the resonant frequency determined from each plane.

I. In the event of more than on resonant frequency in a given plane, record the most severe resonance.

II. If resonant frequencies appear equally severe, record each resonant frequency.

III. If no resonant frequency occurs for a given plane within the prescribed range, 30 hertz must be recorded.

(4) Endurance Test

(a) Vibrate the test unit in each plane at its resonant frequency for a period of 1 hour at amplitude resulting in 0.5g acceleration.

(b) When more than one resonant frequency has been recorded, the test period of 1 hour must be divided equally between the resonant frequencies.

(c) The total time of the endurance test must be limited to 3 hours, 1 hour in each of three mutually perpendicular planes.

(5) Disposition of Equipment under Test

(a) Examine the test unit to determine that no physical damage has resulted from the vibration tests.

(b) Check the test unit to determine that it is functionally operable in all modes of its prescribed operation.

(c) The test unit may be removed from the test table. Upon satisfactory completion of the vibration test, proceed with the shock (impact) test.

u. Shock (Impact) Test

(1) Purpose of Test. The purpose of this test is to determine that the test unit is capable of withstanding the shock (impact) to which it may reasonably be subjected during handling and transportation in the process of installation, repair, and replacement. It is to be noted that the test unit is not, at this time, in its shipping carton.

(a) Fasten the test unit firmly to the specimen table. In each of its three planes the test, drop the unit from a calibrated height to result in a shock force of 10g.

(2) Test Equipment Requirements

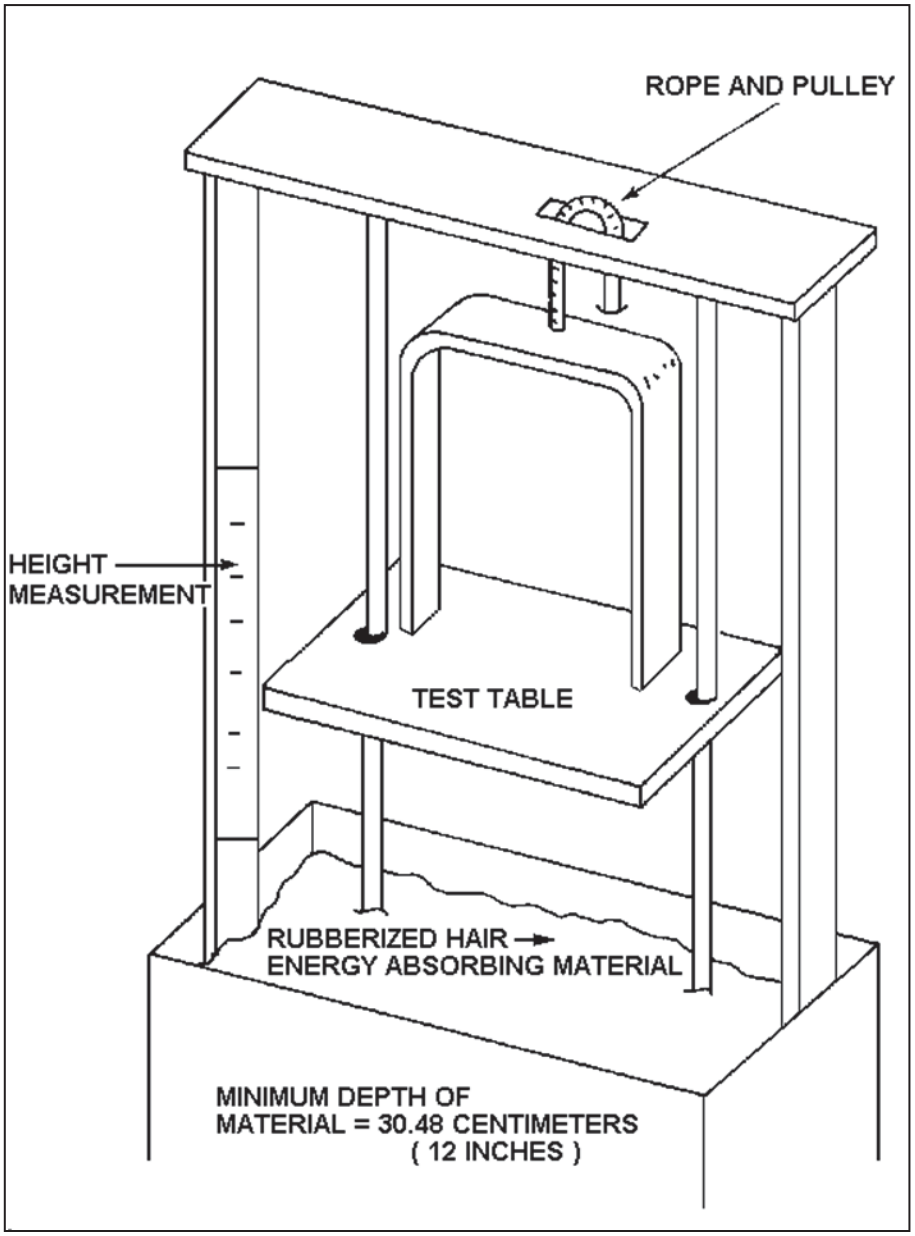
(a) Shock (impact) test fixture equivalent to that suggested by the simplified sketch shown in Figure 2.

(b) The test table must have a surface area sufficient to accommodate the test unit.

(c) Calibrate the test table and the items tested as indicated. This shock test defines the test shock to be 10g (+/-1g).

I. Measure calibration of the test equipment for these shock tests by three accelerometers having fixed shock settings of 9g, 10g, and 11g. They must be Inertia Switch Incorporated ST-355, or the equivalent. Attach these devices rigidly to the test table.

Figure 2
Shock Test Fixture



II. Calibration of the fixture for each item to be tested is as follows:

i. Place a dummy load weighing within 10 percent ofthe test unit on the table.

ii. Reset the three accelerometers and drop the test table from a measured height.

iii. Observe that the accelerometers indicate the following: Activate the 9g accelerometer; the 10g unit may or may not be actuated; the 11g unit must not be actuated.

III. Repeat calibration test (a) and (b) adjusting the height of the drop until, on ten successive drops, the following occurs:

i. The 9g unit is actuated ten times.

ii. The 10g unit is actuated between four to eight times.

iii. The 11g unit is not actuated on any of the ten drops.

(3) Test Procedure

(a) The calibration height of the drop for the particular item under test as determined in Test Equipment Requirements must be used in this procedure.

(b) Secure the test unit to the test table surface so that the test unit rests on one of its three mutually perpendicular planes.

(c) Raise the test table to the calibrated height.

(d) Release the test table from the calibrated height, allowing a free fall into the box of energy absorbing material below.

(e) Repeat the drop test for each of the remaining two mutually perpendicular planes, using the same calibrated height for each drop test of the same test unit.

(f) The observations of the accelerometer for the three tests of the test item are:

I. The 9g unit is actuated for all three tests. (Repeat the calibration if the unit is not actuated.)

II. The 10g unit may or may not be actuated in these tests.

III. The 11g unit is not actuated on any drop. (If the unit is actuated, repeat the calibration only if the test unit has suffered damage.)

(4) Disposition of Test Unit

(a) Check the test unit for any physical damage resulting from the drop tests.

(b) Check the test unit to determine that it is functionally operable in all modes of its prescribed operation.

(c) Satisfactory completion of all environmental tests, including the shock (impact) is required.

v. Power Interruption Test Procedures. Conduct the following power interruption tests at low input voltage (100 VAC) and high input voltage (135 VAC) at -37 degrees C, and +74 degrees C.

(1) Short Power Interruption. While the Test Unit is cycling through normal operations, remove the input voltage for a period of 475 milliseconds. Upon restoration of the input voltage, check to insure that the Test Unit continues normal operation as though no power interruption has occurred. Repeat this test three times.

(2) Voltage Variation. All circuits of the Test Unit must be subjected to slowly varying line voltage during which the Test Unit must be subjected to line voltage that is slowly lowered from a nominal 120 VAC line voltage to 0 VAC at a rate of not greater than 2 Volts per second. The line voltage must then be slowly raised to 100 VAC at which point the Test Unit must resume normal operation without operator intervention. Perform this test at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

(3) Rapid Power Interruption. Subject the Test Unit to rapid power interruption testing of the form that the power is off for 350 milliseconds and on for 650 milliseconds for a period of 2 minutes. Perform power interruption through electromechanical contacts of an appropriate size for the load. During this testing, the controller must function normally and continue normal sequencing (operation) at the conclusion of the test. This test must be performed at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

2.07 TYPE 2070 CONTROLLER UNIT

A. General

1. Module Descriptions. The Controller Unit is composed of the Type 2070 Unit CHASSIS, along with other modules and assemblies. The following is a list of Type 2070 versions, their interface rolls and composition:

Unit Version	Description
Type 2070LX Unit Type 2070LN Unit	LITE Unit mates to the 170 & ITS cabinets. It consists of: UNIT CHASSIS, 2070-1C CPU, 2070-2A (2B if NEMA CABINET), FI/O, 2070-3B FRONT PANEL and 2070- 4 B POWER SUPPLY

2. Unit Configuration. The Type 2070 Controller Unit Version defines the module composition to be delivered as follows:

No.	Item	Description	Composition	
			2070LN	2070LX
1	-	Unit Chassis	Y	Y
2	2070-1C	CPU Module	Y	Y
3	2070-2A	Field I/O Module for 170 type cabinet	-	Y
7	2070-2B	Field I/O Module for ITS & NEMA type cabinets	Y	-
5	2070-3B	Front Panel Display	Y	Y
6	2070-4B	Power Supply 3.5 AMP	Y	Y
7	2070-7A	Serial Communication	Y	Y

3. Metalwork. The CHASSIS Top and Bottom, Internal Structure Supports, Back Plane Mounting Surface, Module Plates, Power Supply Enclosure, and Front Panel must be made of 63-gauge minimum aluminum sheet. The CHASSIS Side panels must be 80-gauge minimum sheet.

4. Power Fail and Power Restoration Operation. It is noted that the Power Failure Power Restoration operations of this unit are specific to the requirements of the user. All associated modules are to comply to said operations.

5. Power Limitations. 2070 UNIT module / assembly power limitations are as follows:

Types	+5VDC	+12VDC ISO	+12VDC ser	-12 VDC ser
MCB	750 milliamperes	-----	-----	-----
TRANS BD	750 milliamperes	-----	-----	-----
2070-1C	1.0 amperes	250mA	-----	-----
2070-2A FI/O	250 milliamperes	750 milliamperes	-----	-----
2070-2B FI/O	250 milliamperes	500 milliamperes	-----	-----
2070-3B FPA	500 milliamperes	-----	50 milliamperes	50 milliamperes
2070-7 All Comm	250 milliamperes	-----	50 milliamperes	50 milliamperes

B. Type 2070-1 CPU Module

1. Type 2070 - 1C Configuration. The TYPE 2070-1C CPU must be a single board module meeting the 2X WIDE board requirements. The module must be furnished normally resident in MOTHERBOARD Slot A5. The module must meet the following minimum requirements:

a. The Model 2070-1C Module shall be provided with an Application Program Interface (API) compliant to the latest published ASHTO/ITE ATC API Standard. A copy of this API standard shall be provided separately at no additional cost upon request. At the time of this writing the latest published standard is API 5401 v2.17.

b. ATC 5.2b, except / in addition to where noted below:

(1) A processor with a minimum MIPS of 400 calculated using the Dhrystone v2.1 benchmark at 25°C.

(2) A minimum of 64 megabytes (MB) of DRAM or equivalent volatile memory for application and OS program execution.

(3) A minimum of 128 MB of FLASH for storage of OS Software and user applications.

(4) Prior to 1 May 2017 a minimum of 1 MB of SRAM memory for non-volatile parameter storage; starting 1 May 2017 a minimum of 2 MB minimum of SRAM memory for non-volatile parameter storage.

(5) The 1C card shall provide the standby power required for supporting the SRAM and RTC.

(6) A Utility Program shall be provided that would allow the user to upgrade (re-flash) the Boot Image for the Linux Kernel.

(7) A re-flash utility and the procedures for its use in PDF form.

(8) All Linux Software, except for loadable modules, shall comply with the GPL license as published by the Free Software Foundation.

(9) One USB 2.0 or greater compliant port.

(10) Two 10/100 Ethernet ports; Ethernet Ports shall be marked port 1 and port 2.

c. Host Board:

(1) Single board module meeting Caltrans 2x WIDE board requirements.

(2) Provides two DIN sockets and mounting standoffs for the connection of the 2070-1C engine Board.

(3) Not less than two Ethernet ports used to route ENET1 and ENET2 signals from Engine Board to the front panel.

(4) Datakey receptacle capable of housing 3.3 VDC 5.0.

(5) USB 2.0 or greater full speed port for memory.

d. Front panel:

(1) 2070 Standard 1x module.

(2) USB port.

(3) Data key socket.

(4) 256 bytes or greater SPI EEPROM.

(5) Two RJ45 Front Panel Ethernet jacks.

(6) 25 pin D Socket Type port.

e. Standard Features:

(1) Open source U-boot loader.

(2) ATC 5.2b standards compliment CPU Engine Board.

(3) Full support for all required ATC 5.2b software drivers.

(4) Compatible with the latest Caltrans QPL approved 2070E hardware. At the time of this writing the latest approved hardware specification is TEES 2009. Note: this does not require the 1C module to be on the Caltrans QPL, it requires that the 1C module be compatible with the other hardware on the Caltrans QPL.

(5) Compatible with legacy 2070s (TEES 2002 to present). The City of Houston operates 2070 controllers in NEMA TS1, 332 type, ITS, and other type cabinets.

(6) Capable of running multiple independent applications.

(7) Board - support toolchain package with all necessary libraries for 3rd party software development. A copy of this toolchain package shall be provided separately at no additional cost upon request.

(8) Standards based API library which allows applications to share front panel and field I/0 resources.

(9) Support SD card memory and provided with an industry standard SD card socket.

f. Operating system:

(1) Compliance with the ATC Standards v5.2b.

(2) Must be able to download software by USB.

(a) A dual option to download from Windows software over Ethernet is acceptable.

(3) SD card communication shall be addressed using SP4 for consistency with ATC standard 6.24.

C. Type 2070-2 Field I/O Module (FI/O)

1. Type 2070-2A Module. This module shall comply with the requirements in Specification ATC 5202 v03.04 section 3.10.

D. Type 2070-3 Front Panel Assembly

1. The Type 2070-3 Front Panel Assembly (FPA) shall comply with specification ATC 5203 section 3.11 selecting option 3B.

E. Type 2070-4 Power Supply Module

1. The Type 2070-4A Power Supply Module shall comply with standard ATC 5202 v03.04 section 3.12.

F. Unit Chassis

1. General

a. The Chassis consists of the metal housing, Serial Motherboard, Back-plane Mounting Surface, Power Supply Module Supports, slot card guides, Wiring Harnesses, and Cover Plate(s).

b. All external screws must be countersunk and be Phillips flat head stainless steel type.

c. The housing must be treated with clear chromate and the slot designation labeled on the back-plane mounting surface above the upper slot card guide.

d. The Chassis must be cooled by convection only. The top and bottom pieces of the housing must be slotted for vertical ventilation.

2. Serial Motherboard. Serial Motherboard must function as support for its connectors, A1 to A5 and FP, and as the interface between the CPU and the dedicated modules/Front Panel carrying both serial communications, logic, and power circuits. The PCB must be multi-layered, with one layer plane assigned to DC Ground.

a. A wiring harness PS2 must be provided between the Type 2070-4 Power Supply and the Motherboard PCB (provide strain relief). Test points must be provided on the FPA side of the Motherboard for PS2 lines.

b. A wiring harness FP must be provided, linking the Motherboard with the FPA.

G. Details: reference standard ATC 5202 v03.04 Appendix A for figures and pinouts on 2070 modules.

2.08 TYPE 2070 PERIPHERAL EQUIPMENT

A. General Notes:

1. The 2070-7x modules must provide circuitry to disable its Channel 2 and EIA-232 control lines (TX, RX, RTS, CTS, and DCD) when a ground true state is present at Connector A1, Pin B21 (C50 Enable). The disable lines must be pulled up on this module.

2. Line drivers/receivers must be socket mounted or surface mounted.

3. Isolation circuitry must be opto- or capacitive-coupled isolation technologies. Each module's circuit must be capable of reliably passing a minimum of 1.0 megabits per second.

4. The communications modules must be "Hot" swappable without damage to circuitry or operations.

B. Type 2070-7A Async Serial Communications Module

1. Circuitry. Two circuits, designated CIRCUIT #1 and CIRCUIT #2, must be provided. Their functions are identical, except for the CPU Serial Communications Port and external connector (CIRCUIT #1 to SP1 [or SP3] and Connector C21S and CIRCUIT #2 to SP2 [or SP4] and Connector C22S).

2. 2070-7A. Each circuit must convert its EIA-485 signal lines (RX, TX, RTS, CTS and DCD) to / from board TTL Level Signals; isolate both signal and ground; and drive / receive external EIA-232 devices via C21 / C22 Connectors. Connectors must be DB-9S type.

3. Indicators. Each circuit signal TX and RX line must have an LED Indicator mounted on the front plate and labeled to function.

2.09 NEMA MODULE

A. The 2070-8 module shall comply with standard ATC 5202 v03.04 section 3.20.

PART 3 EXECUTION – Not Used

END OF SECTION

SECTION 16732

UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM FOR TRAFFIC SIGNAL CABINETS

PART 1 GENERAL

1.01 SECTION INCLUDES

Furnish, install, and make fully operational an Uninterruptable Power Supply (UPS) system at designated locations as shown on the plans and as detailed in accordance with these specifications. Use the same manufacturer and model for each Uninterruptable Power Supply (UPS). The Uninterruptable Power Supply provides reliable power to a traffic signal intersection (vehicle and pedestrian) in the event of utility failure or interruption. The UPS system shall also act as a power conditioner and/or voltage regulation device.

1.02 MEASUREMENT AND PAYMENT

A. Measurement

This item will be measured as each unit furnished, installed, made fully functional and tested in accordance with these special specifications or as directed by the Engineer. The UPS system will include, but is not limited to an automatic bypass switch, power transfer relay, an inverter/charger, batteries, battery charge management device, wiring, external cabinet, all mounting hardware, manufacturer's operation manual, required testing results, manufacturers technical specification, and the cost of all materials, training, warranty, equipment, and all accessories necessary to the complete installation of the unit.

B. Payment

Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Uninterruptable Power Supply". This price will include all equipment described under this item with automatic bypass switch, power transfer relay, an inverter/charger, batteries, battery charge management device, wiring, external cabinet, mounting hardware; all documentation and testing and will also include the cost of furnishing all labor, materials, software, warranty, training, equipment, and incidentals.

PART 2 PRODUCTS

2.01 MATERIALS

Provide an Uninterruptable Power Supply (UPS) unit that meets the following requirements.

A. GENERAL REQUIREMENTS

The UPS system shall be capable of operating a signalized intersection (700 watt load) for 4 hours of full runtime when utility power is disabled and under ambient temperature of 251zC. The UPS system shall switch the intersection to flash mode when approximately 40% of the battery charge is remaining, via relay contact connection points on the front panel of the unit. The UPS system shall operate the intersection in the flash mode of the operation (350 watt load) for an additional 2 hours. The UPS system shall be rated for a minimum 2,000 watt load capacity.

B. DISPLAYS, CONTROLS, DIAGNOSTICS AND MAINTENANCE

1. The UPS system shall include a front panel display. All applicable programmable functions of the operational methods described in this specification shall be viewable through the front panel display.

2. All events described in Operations Section shall be viewable from the front panel display.

3. The UPS system software shall be programmable from the front panel of the inverter/charger by means of a keyboard or momentary buttons allowing the user to step through menu driven software.

4. A 10/100 Ethernet port shall be provided on the front panel of the inverter/charger.

5. UPS system software shall be provided for the operational needs of the UPS system. The user/operator shall be able to access all system software via the Ethernet port and RS232 port on the front panel of the inverter/charger. The user shall be able to read logged events and/or change programmable parameters from the keyboard, laptop, or local area network via Ethernet port.

6. System software shall be upgradable via the RS232 and Ethernet ports on the front panel of the inverter/charger.

7. All upgrades for software shall be provided for hardware components for the duration of the warranty period at a minimum.

C. INVERTER/CHARGER

Provide an inverter/charger that has the following features:

1. When utility line voltage is out of normal operating range (typical 100V AC to 135V AC), the inverter/charger shall provide voltage regulation and/or power conditioning to the inverter line voltage using one or more of the methods described in Section 3.0 of this specification. When utility line voltage is present, it shall act as a charging device for the batteries.

2. Operating temperature range for both the inverter/charger unit and power transfer relay shall be -34ºC to 74ºC.)

3. When battery power is used, the UPS system output voltage shall be between 110V AC and l25V AC, pure sine wave output, :S 3% THD, 60Hz ± 3Hz.

4. As a minimum the inverter/charger shall be rated for 2,000 watts of continuous power from the unit.

D. AUTOMATIC BYPASS SWITCH

Provide an automatic bypass switch that has the following features:

1. The automatic bypass switch shall be provided as a separate unit external to the inverter/charger unit. The automatic bypass switch shall be 2 position and rated at a minimum of 240V AC/30 amp. A UPS supply breaker rated at 240V AC/30 amps shall be provided for the 120V AC input to the inverter/charger.

2. When the automatic bypass switch is in the "on" position and the supply breaker is "on", the UPS system is connected to utility line voltage and its output is connected to the cabinet service panel. If the utility line voltage is deactivated, the UPS system will automatically switch over to battery power.

3. When the automatic bypass switch is in the "off" position, and the supply is "on", utility line power is provided to the cabinet service panel and the inverter/charger allowing equipment to be tested without interrupting power to the traffic signal load.

4. When the automatic bypass switch is "off" and the supply breaker is "off", the utility line voltage will feed power directly to the traffic signal cabinet service panel and power to the inverter/charger will be deactivated allowing the user to service UPS equipment.

E. BATTERIES

Provide batteries for the Uninterruptable Power Supply System that have the following features:

1. Individual batteries shall be 12V type rated for at least 165 minutes of runtime, and shall be easily replaced and commercially available for purchase as common off the shelf equal.

2. Batteries shall be sized and rated to operate at 700 watt load for 4 hours (normal operation) followed by a 350 watt load (flash operation) for 2 hours.

3. Battery configurations shall consist of 12V batteries arranged in one of the following arrangements: 48V, 60V, 72V, 84V, 96V.

4. Batteries shall be deep discharge sealed prismatic valve regulated acid (VRLA) AGM or Gel cell batteries.

5. Batteries shall operate over a temperature range of -34ºC to 74ºC.

6. Batteries shall not be charged when battery temperature exceeds 50ºC ± 3ºC.

7. Batteries shall indicate maximum recharge data, recharging cycles, and manufacture defaults on the inverter. Batteries shall not allow the recharging process to exceed the batteries maximum values.

8. Battery interconnect wiring shall connect to the inverter unit via modular harness with red and black cables. Harness shall have battery ring lug at the battery end of the cables that are .40" in diameter and connect to batteries using a ¼" – 20 UNC bolt that is ¾" in length.

9. Batteries shall have maintenance free threaded inserts sized to fit a ¼" – 20 UNC bolt that ¾" in length.

10. Insulated covers shall be provided at the connection points of the batteries to prevent accidental shorting.

11. Battery harness and cabling shall be a minimum of 6ft in length

12. Batteries weighing more than 50 pounds shall be provided with a handle or hand strap allowing the user to carry or move the battery without the use of other equipment.

F. BATTERY MONITORING SYSTEMS

Provide a temperature compensated battery charging system and a temperature sensor that have the following features:

1. The UPS system shall use a temperature compensated battery charging system. The charging system shall compensate over a range of 2.5 to 4mV/1zC per cell.

2. The temperature sensor shall be used to monitor the temperature and regulate the charge rate of the batteries. Unless required otherwise by the plans the temperature sensor wire shall be as follows:

   a. Temperature sensor wire shall be a minimum of 8 feet in length.

b. Should the temperature sensor fail, the inverter/charger shall not allow the UPS system to overcharge the batteries. The UPS system shall provide an alarm should the temperature sensor fail.

c. Recharge time for the batteries to 80% or more of full battery charge capacity shall not exceed 20 hours at 701zF.

d. Batteries shall not be charged when the battery temperature exceeds 501zC ± 31zC.

e. The UPS system shall monitor battery strings within a system and set a fault indicator if the battery voltage falls below normal operating voltages.

G. EXTERNAL UPS SYSTEM CABINET

Provide an external cabinet to house all of the UPS system components that has the following features:

1. The external cabinet shall be NEMA Type 3R all aluminum with stainless steel hardware, or equal, approved by the City of Houston Traffic Signal Maintenance Shop. The external cabinet shall be sized to house all of the UPS system components including batteries and designed to mount to the side of the traffic signal cabinet. Dimensions of the external cabinet shall not exceed 56” height x 26” width x 18” depth. The cabinet shall be mounted in a manner that does not obstruct pedestrian travel on adjacent sidewalk.

2. The cabinet shall be provided with one door in front that will provide access to the cabinet. The door shall be provided with three hinges with non-removable stainless steel pins, or a full-length piano hinge with stainless steel pins spot welded at the top of the hinge. The hinges shall be mounted so that it is not possible to remove them from the door or cabinet without first opening the door.

3. The cabinet door shall be fitted with a Number 2 Corbin lock and a cast aluminum or chrome plated steel handle with a 16mm (minimum) diameter shaft (or equivalent cross-sectional area for a square shaft) and a three point latch. The lock and latch design shall be such that the handle cannot be released until the lock is released. One key shall be provided for each cabinet. A gasket shall be provided to act as a permanent dust and weather resistant seal at the cabinet door facing. The gasket material shall be of a nonabsorbent material and shall maintain its resiliency after long term exposure to the outdoor environment. The gasket shall have a minimum thickness of 6.25mm. The gasket shall be located in a channel provided on the cabinet

or on the door(s). An "L" bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniform dust and weather resistant seal around the entire door facing. Any other method is subject to written purchaser approval during inspection of an order.

4. The intake for the vent system shall be on the lower section of the cabinet front door and filtered with a washable, metal air filter. The filter shall be securely mounted so that any air entering the cabinet must pass through the filter. The cabinet opening for intake of air shall be large enough to use the entire filter. The air intake and exhaust vent shall be screened to prevent entry of insects. The screen shall have opening no larger than 8.1mm^2. The total free air opening of the exhaust vent shall be large enough to prevent excessive back-pressure on the fan.

5. The external cabinet must contain a fan mounted in the top of the cabinet. The fan must be 48Vdc and thermostat controlled. It must turn on when the inside temperature of the cabinet reaches or exceeds 49^{o}C (120^{o}F) and turn back off once the inside temperature of the cabinet returns to 32^{o}C (89^{o}F).

6. The external UPS system cabinet shall include a red LED mounted on the top of the cabinet that is visible from the street. This indicator shall be connected to light the LED "on" to allow maintenance to know when the intersection is running off UPS power. When the intersection is operating on utility line voltage the LED will be "off" (not illuminated).

H. OPERATION

The UPS system shall operate in one or more of the following methods:

1. Line Interactive (Buck and Boost) Method

   a. When the buck and boost functions are enabled they shall set the upper and lower control limit allowable for the utility line voltage. If the utility line voltage fails within the parameters set by buck and boost, then the UPS system shall continue to operate the intersection under utility line power. If the utility line voltage fluctuates above or below the buck and boost values, the UPS system shall raise or lower the voltage by approximately 10%-15% of the utility line voltage in an attempt to bring the voltage back into the upper and lower control limits set by buck and boost. Buck and boost shall have preset manufacturer defaults.

   b. If the utility line voltage falls above or below the functional capabilities of buck and boost, then the UPS system shall transfer power from the utility line

voltage and the inverter/charger shall operate the intersection from battery power converting DC voltage to AC.

2. Continuous Operating Mode, Double Conversion Method

a. Using the continuous operating mode buck and boost functions are disabled and the UPS system operates continuously converting the utility line voltage, 120V AC, to DC voltage, then back to 120V AC, supplying the cabinet with inverter line power. Should the utility line voltage fail, the UPS system will continue to supply inverter line power to the cabinet via the UPS system.

3. General Operation Requirements

a. The UPS system shall be capable of providing 2,000 watts active output capacity, with a minimum of 80% inverter efficiency. The inverter/charger shall be capable of operating at a 2,000 watt continuous load.

b. When the batteries are fully charged, ensure the UPS system provides power to run an intersection and all peripherals for a minimum of 4 hours of semi-actuated runtime (700 watt load), then switch to flash mode for a minimum of 2 hours of flash runtime (350 watt load).

c. When the system is running on battery power, the UPS system shall allow the user to select a voltage (typically 48V) at which the transition from normal operating loads (700 watts) to flash mode (350 watts) will occur via a set of relay contacts or connection points on the front panel of the inverter/charger.

d. The transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from the batteries, shall be less than 65 milliseconds. The same allowable transfer time shall also apply when switching from inverter line voltage to utility voltage.

e. The UPS system shall bypass utility line voltage, whenever the utility line voltage is outside the manufacturer's defaults or a user programmed voltage range $\pm$ 5V AC.

f. When the utility line power has been restored to a normal operating voltage for more than 30 seconds, the UPS system shall transfer from battery back to

utility line mode. The UPS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

g. The UPS system shall be compatible with ITS models, NEMA, and Model 170/2070, controller and cabinet components for full runtime operation.

h. The UPS system shall be shelf mounted within its own side mounted external cabinet. The bypass switch can be mounted inside the traffic signal cabinet or in the side mounted external cabinet along with the batteries. The interconnection cables shall be no less than 10 feet in length. Relay contact wiring for relay contact closures shall be no less than 6 feet long of #10 AWG wire. Wire size shall be sized accordingly to manufacturer recommendations for any cable lengths greater than 10 feet.

i. The UPS system shall have lightning surge protection compliant with IEEE/ANSI C.62.41, latest revision and meeting all current UL 1449 standards.

j. The UPS system and batteries shall be easily replaced and provided with all needed hardware and software. The UPS system shall not require any special tools for installation.

k. The UPS system shall operate with an automatic “fail safe” mode. Should a breaker trip on the inverter/charger and/or the power transfer relay, the unit will automatically default to utility line power and bypass the UPS system.

l. The UPS system shall be capable of logging up to 100 events. Events shall date and time stamp faults with the AC line voltage and UPS battery voltage. At a minimum, the following conditions shall be recorded as an event:

i. The UPS system shall record utility line voltage occurrences whenever the line voltage falls above or below the upper and lower control limits or manufacturer preset defaults. When this condition occurs, it shall be record as an event.

ii. Whenever the UPS system automatically switches to battery power this shall be recorded as an event.

iii. Whenever the UPS system returns to utility line power from battery power, this shall be recorded as an event.

iv. The UPS system shall be capable of self-monitoring and record failure of any UPS system components as an event.

2.02 CONSTRUCTION

A. GENERAL

Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

Design the equipment for ease of maintenance. Provide component parts that are readily accessible for inspection and maintenance. Provide test points that are for checking essential voltages and waveforms.

B. ELECTRONIC COMPONENTS

Provide this item in accordance with Special Specifications "Electronic Components".

C. MECHANICAL COMPONENTS

Provide external screws, nuts and locking washers that are stainless steel; no self-tapping screws will be used. Provide parts made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass. Protect materials from fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

D. DOCUMENTATION REQUIREMENTS

1. Operation and maintenance manuals shall be provided. The operation manual shall include a block diagram schematic of all systems hardware components. The manual shall include instructions for programming and viewing software features. The manual shall include all uploading/downloading (communications protocol) requirements via R232 port and Ethernet port.

2. Board level schematics shall be provided when requested.

3. Board level schematics shall be provided when requested.

E. TESTING

City of Houston reserves the right to do testing on UPS systems to ensure quality assurance before installations and random sampling of units being provided to the City. UPS systems that fail will be removed from the Prequalified Products List (QPL).

City of Houston QPL testing procedures will include the following:

1. UPS system shall comply with all the criteria of this specification.

2. Event logging for fault/alarm conditions.

3. System will demonstrate one or more of the operation methods described in Section 3.0.

4. UPS system will operate at 700 watt load (minimum 4 hours), system will transfer to flash mode and operate at 350 watt load (minimum 2 hours) under battery power and at ambient temperature +251zC, total length of test 6 hours.

5. All component of the system shall be tested in environmental chamber (temperature ranges from -301zC to 741zC).

F. EXPERIENCE REQUIREMENTS

Meet the following requirements, as a minimum, for Contractor or designated subcontractors involved in the installation and testing of the UPS system:

Three years' experience in the installation of UPS equipment. Two installed systems where UPS systems are installed and the systems have been in continuously satisfactory operation for at least two (2) years. Submit as proof, photographs or other supporting documents, and the names, addresses and telephone numbers of the operating personnel who can be contacted regarding the system.

Provide necessary documentation of subcontractor qualifications pursuant to contract award.

G. TECHNICAL ASSISTANCE

Ensure that a manufacturer's technical representative is available on site to assist the technical personnel at each installation site and with UPS equipment installation and communication system configuration.

Do not execute the initial powering up of the UPS equipment without the permission of the manufacturer's representative.

H. WARRANTY

1. All components of the UPS system will be warranted by the manufacturer for five years following the acceptance of the system by City of Houston. The warranty will include the specific installation characteristics for the geographic region and project limits.

2. Batteries shall be warranted for full replacement for 5 years. Batteries shall be defined as bad, if they are not able to deliver 80% of battery rating.

PART 3 EXECUTION

A. SUBMITTALS

Manufacturers' cut sheets / specifications and software for all equipment proposed under these specifications shall be submitted to the City of Houston's Traffic Signal and Operations branch at Houston TranStar (713-881-3172) prior to construction.

END OF SECTION

SECTION 16738

WIRELESS COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

This specification sets forth the minimum acceptable physical, electrical, installation, configuring and testing of wireless communication system into controller cabinets at intersections throughout the City of Houston. All items furnished under this contract shall be new unused materials of the latest product in production to the commercial trade, and shall be of the highest quality as to materials and workmanship.

A. Description. This Item governs the furnishing and installation of Wireless Ethernet Radio (WER) as shown on the plans and as directed by the City's Intelligent Transportation Systems (ITS) Engineer.

Provide all similar WER from the same manufacturer. Provide new, corrosion resistant materials furnished, assembled, fabricated or installed under this Item in strict accordance with the details shown on the plans and in the specifications.

Provide an interference analysis for each location to identify potential sources of interference. Adjust antenna polarities and channel plans on equipment to minimize interference from other sources. If the interference analysis shows possibility for interference at the City sites, conduct in-field monitoring to determine if actual interference exists.

Provide all licenses, where required, for any software, hardware, or equipment in the system. Supply, from the equipment manufacturer, a medical statement as to the safety of the unit to the general public (example: Pacemakers, etc.).

B. Materials. Provide a Wireless Ethernet Radio (WER) that is a point to point or point to multi-point, license-free, radio a minimum data rate of 512 kbps at a 20 mile range.

Supply a WER that uses Frequency Hopping Sequence Spread Spectrum technology. Supply a WER with a serial port that can be used for configuration. Provide an auto-sensing Ethernet port for the connectivity. Furnish a radio that has frequencies which are software selectable with a minimum of 139 channels in the 900 MHz band. The radio will be software configurable via a serial port or with telnet or WER Graphic User Interface through the Ethernet port.

Equip the WER with a minimum of one RP-TNC connector that allow the deployment of omni-directional or unidirectional external antennas.
Use power and signal cables that are, at a minimum, UV rated Category 6 cables.

C. Contractor Experience Requirements. Minimum requirements for the Contractor or designated subcontractors involved in the installation and testing of the WER are:

1. Three years experience in the installation of WER System.

2. Two installed WER systems where Systems have been in continuously satisfactory operation for at least 1 year. Submit as proof, photographs or other supporting documents, and the names, addresses and telephone numbers of the operating personnel who can be contacted regarding the system.

3. Provide all necessary documentation of subcontractor qualifications pursuant to contract award.

D. Equipment.

1. Furnish WER that meet the minimum requirements:

1. Radio	
Output power (adjustable)	100mW to 1W, user configurable
Frequency Range	902-928 MHz
Receive Sensitivity	-109 dBm @ 256 Kbps @BER=10E-6 -100 dBm @ 512 Kbps @BER=10E-6
RF Technology	Frequency Hopping Spread Spectrum 200 KHz channel spacing
Wireless Data Rate (Mbps)	512 kbps
Range	Up to 45 km (30 miles) at 512 Kbps
Certification	Federal Communications Commission (FCC)
2. Network Support	
Network Connection	10/100BaseT, IEEE 802.3 compliant, RJ-45
VLAN (802.1q) Compliance	Yes
3. Wireless Networking	
Network Topologies	Point-to-Point, and Point-to-Multi-point, Multi-point to Point, Peer
4. Security	256 AES
Authentication	802.1X support including LEAP to yield mutual authentication and dynamic per-user, per-session encryption keys
Encryption	Temporal Key Integrity Protocol (TKIP), Key hashing (per-packet keying) and Message Integrity Check (MIC) Advanced Encryption Standard (AES)-ready
5. Management	
Remote Management	Telnet, HTTP, FTP, Trivial FTP (TFTP), SNMP

Management port	RS-232 Serial
6. Receiver	
Type	Double Heterodyne
Maximum RF Input	-20 dBm
Unfaded BER	Typically Better than BER 10^{-6}
Frequency Stability	+/-5 ppm
7. Antenna	
External	Unidirectional (Yagi)
External	Omni-directional
8. Status Indicators / Diagnostics	
External LED Indicators	LEDs: Power, Transmit Data and Receive Data
Alarms	Radio TX, Radio RX, BER Threshold
Status	NMS IP Addresses, BER, TX Power, Receive Signal Level, Loopback Test status, Ethernet Input
Configuration Commands	NMS IP Address, TX Power, TX Mute, ATPC, Frequency, RSL, BER Alarm, Loopback Tests, BER Tests
Diagnostic Testing Features	Bit Error Rate (BER), Local/Remote/RF Loopback Performance Monitoring Receive Signal Strength Indicator (RSSI)
Environmental Operating Range	Temperature -40ºC to +80ºC Humidity 10% to 95% (non-condensing)

2. Mechanical Requirements.

   a. Provide equipment that is modular in design such that it can be easily replaced in the field.

   b. Clearly identify the unit with name, model number, serial number, blank line for IP addressing and any other pertinent information required to facilitate equipment maintenance.

   c. Supply a WER with maximum dimensions of 13.0 in. x 13.1 in x 3.12 in and weigh 8 lbs maximum, in a NEMA 4 rated enclosure.

   d. Coat printed circuit boards with a clear-coat moisture and fungus resistant material (conformal coating).

3. Radio Antenna. Furnish radio antennas per the WER manufacturer requirements. As a minimum, antennas should have the following characteristics:

   a. Unidirectional (Yagi), Minimum 9 dB gain (dB reference to half wave dipole)

b. Omni-directional, Minimum 6 dB gain (dB reference to half wave dipole

c. Wind Rating – 125 miles per hour

d. Use heliax type for all cable runs. Install cable connectors in accordance with manufacturer's recommendations. Install cable as shown on the plans or as directed by the City's ITS Engineer. The heliax type cable with the following minimum characteristics:

1)	Impedance:	50 Ohm
2)	Attenuation:	0.8 dB/100 ft or less @ 894 MHz
3)	Velocity Factor:	90% or better
4)	Nom. Capacitance:	25 pF/ft or less
5)	DC Resistance:	0.5 Q/meter
6)	Core insulation:	Semi solid polyethylene or better
7)	Center Conductor:	Solid
8)	Outer diameter:	0.405 inches outer diameter
9)	Shield:	Greater than 95%
10)	Dielectric:	Foam PE
11)	Outer jacket:	Black PE PVC, UV protected

4. Environmental Requirements. Furnish equipment that is capable of continuous operation over a temperature range of -40° to +175°F and a humidity range of 0% to 90% (non-condensing).

E. Manufacturing

1. Utilize the latest available techniques for equipment design and construction, with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

2. For all external screws, nuts, and locking washers, use stainless steel. Do not use self-tapping screws unless specifically approved by the Engineer.

3. Fabricate all parts of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass.

4. Protect all materials used in construction from fungus growth and moisture deterioration.

5. Separate dissimilar metals by an inert dielectric material.

6. System Installation. Provide and install all materials, including support, calibration and test equipment, to ensure an operating and functional wireless system. This includes installation of WER equipment with power and data cables, and the Power and Grounding System. Prior to beginning installation, inspect each site to verify suitability of installation and submit an installation design and a grounding and lightning protection design to the

Engineer for approval prior to installation. This installation includes:

a. Antenna Mounts. Providing and installing antenna mounts, standoffs, brackets and hardware, transmission line, hanger kits and grounding kits. Install all antennas at specified center lines. Perform antenna alignment for each path and compare with path calculations.

b. System Power and Grounding. Describe the proposed grounding and lightning protection design. Connect equipment to the 115 Volt circuits provided at the sites. Bond all equipment racks in accordance with the approved Installation Specification. Ground all equipment racks to the single- point ground for the site. Provide grounding and lightning protection for all cable runs on the support tower and at the equipment entry point.

c. System Optimization. Following installation of the completed system, optimize the equipment at each site in accordance with the specifications to provide a complete, operational system.

7. Power Requirements. Furnish a WER that operates at input voltage range of +10 -
+48 VDC, from a separate solar power supply to be provided as part of a separate bid item. Maximum allowable power consumption for WER is 2Watts.

a. Wiring. Install wiring meeting the requirements of the National Electrical Code. Cut all wires to proper length before assembly. Do not double back any wiring to take up slack. Neatly lace wires into cable with nylon lacing or plastic straps. Secure all cables with clamps. Provide service loops at all connections.

b. Transient Suppression. On all DC relays, provide diodes or other protective devices across the solenoids and holding coils for transient suppression.

c. Power Service Protection.
   1) Furnish equipment containing readily accessible, manually resettable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection.
   2) Provide circuit breakers or fuses that are sized such that no wire, component, connector, PC board or assembly shall be subjected to sustained current in excess of their respective design limits upon the failure of any single circuit element of wiring.

d. Fail Safe Provision. Design the equipment such that the failures of the equipment will not cause the failure of any other unit of equipment. Provide automatic recovery from power failure within 5 seconds after

resumption of power.

e. Connectors and Harnesses. Make all external connections by means of connectors. Key the connectors to preclude improper hookups. Color code and/or appropriately mark all wires to and from the connectors.

1) Provide connecting harnesses of appropriate length and terminated with matching connectors for interconnection with the communications system equipment.
2) Uniquely color code patch fibers with mixed connectors for easy identification
3) Plate all pins and mating connectors with not less than 20 microns of gold. For connectors utilizing solder type connections, cover each soldered connection with a piece of heat shrink tubing securely shrunk to insure that it protects the connection.
4) Clearly identify all assemblies with name, model number, serial number and any other pertinent information required to facilitate equipment maintenance.

8. Software. Provide any and all programming and software required to support the WER system.

a. Install the programming and software in the appropriate equipment at the time of acceptance testing, for use in the acceptance testing.

b. Provide software updates free of charge during the warranty period.

9. Technical Assistance. Ensure that a manufacturer's technical representative is available on site to assist the Contractor's technical personnel at each installation site and with WER System equipment installation and communication system configuration. Do not power up the WER equipment without the permission of the manufacturer's representative.

System Testing: Conduct System Testing at the manufacturer's facility as well as after installation at the designated City locations:

a. Test each hop of the proposed system. As a minimum, test transmit power and frequency, receiver performance and frequency, proper operation of switch over, proper operation of alarms and switches and bit error rate (BER) testing for the configured hop. Prior to beginning the manufacturer's test, provide the City’s ITS Engineer with a copy of the test procedure as well as the proposed test date(s).

b. Following completion of equipment installation and operational optimization, shall submit the Acceptance Test Plan to the City’s ITS Engineer for review and Approval. During the official Acceptance Testing, provide the technical staff to conduct the measurements and adjustments called for in the testing. The City of Houston reserves the

right to participate in the testing as the Official Test Witness. On each page of the Acceptance Test Document, provide for data recording of the test results, and the name of Contractor's representative conducting the test as well as a suitable field for the test date and signature of City's ITS Engineer. Upon City's approval of the Test Plan and the Test Schedule, the Acceptance Testing may begin. This includes:

c. Intersection-level testing of the individual system paths: testing of the installed system paths includes:
   1) Measuring and recording the transmitter/receiver channel frequency and polarity.
   2) Measuring and recording the transmitter power.
   3) Measure and record the receiver fade margin.
   4) Perform a one hour Bit Error Rate Test (BERT) on the primary equipment and record results.
   5) Verify the operation of all local alarm and control points using the alarm/monitoring equipment provided.
   6) System-level Test: Following intersection-level testing of the individual system paths, test each hop on an end-to-end testing and perform a BERT on the primary equipment.

10. Test and verify the operation of the alarm and monitor equipment in accordance with the Acceptance Test criteria.

11. Measurement. This Item will be paid by each installation at each intersection.

12. Payment. The work performed and material furnished in accordance with this Item and measured as provided under "Measurement" will be paid for by each intersection. This price includes all equipment described under this item with all cables and connectors, mounting assemblies, all documentation and testing; and the cost of furnishing all labor, materials, training, warranty, equipment, and incidentals necessary to complete the work.

PART 2 PRODUCTS – Not Used

PART 3 EXECUTION

3.01 TESTING & TRAINING

Provide a factory certified representative for installation and testing of the equipment. Conduct a test site survey prior to the installation of the equipment. The City reserves the right to conduct own site survey as needed.

When required, provide up to 2 days of training to personnel of the City in the operation, setup and maintenance of the spread spectrum radio system. Provide instruction and materials for a maximum of 20 persons and at a location selected by the City. Provide instruction personnel certified by the manufacturer. The User's Guide is not an adequate substitute for practical classroom training and

formal certification.

Provide updates of the spread spectrum radio software free of charge during the warranty period, including the update to NTCIP compliancy.

3.02 WARRANTY

All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of twenty-four
(24) months. Warranty period shall begin the day the video detection system is activated by the City of Houston, either as new order or warranty repair. The City of Houston's preference is for all non-warranty service to be charged a singular flat rate.

Successful bidder shall bear all expenses connected with return of any material, which the City deems necessary to return for adjustments during warranty period.

Successful bidder shall bear all labor cost associated with warranty items and maintenance in a timely manner; the quality of timely service is determined by the City's ITS Engineer and shall not exceed twenty-four (24) hours from the Time of Notification (TON) to initial field response by the successful bidder or their representative. In essence, the successful bidder shall provide maintenance and field service (i.e. trouble calls) during the warranty period.

Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost.

Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or City's Traffic Engineer's representative, on any special circuitry that may be required in certain applications.

END OF SECTION

SECTION 16750

ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Accessible Pedestrian Push Button Station Assembly with control unit and mounting hardware. The assembly shall be the 2-Wire Navigator Push Button Station and 2-Wire Navigator Central Control Unit (CCU) as manufactured by Polara Engineering, Inc.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Accessible Pedestrian Push Button Stations will be measured by each push button assembly and necessary central control unit.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Accessible Pedestrian Push Button Station." The price shall be full compensation for furnishing, assembling, installing, made fully operational and testing the unit, as well as all mounting attachments, labor, tools, equipment, and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

Provide new materials that comply with the details shown on the plans and the requirements of this specification.

2.02 ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

A. The assembly and manufacturing process for all internal electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

B. Weather-proof speaker protected by vandal proof screen.

C. Central Control Unit (CCU) for the pushbutton detector unit that resides in the Traffic Signal Controller Cabinet capable of controlling a minimum of 12 units using no more

than one pair of wires for each phase. The CCU must be capable of controlling up to 4 phases and all inputs and outputs shall have Transient Voltage Protection.

1. Pedestrian Walk / Don't Walk inputs: optically isolated 80-150 Volts AC/DC 5 mA maximum.

2. General purpose outputs and pedestrian outputs: optically isolated 36 Volts AC/DC peak 0.3A solid state fused contact closure.

3. Fault Output: normally open and closed relay contacts 125 Volts AC/DC 1A maximum.

4. A, B, C, D PBS power outputs: nominal 22 Volts DC, short circuit protected – auto recovering.

5. General Purpose Inputs: 10-36 Volts AC/DC peak 10 mA maximum, optically isolated.

6. Environmental: operating and storage -30˚F (-34˚C) to 165˚F (74˚C) 0-100% humidity non-condensing.

D. Each unit will contain a vibrating tactile arrow to provide a tactile representation of the status of the WALK indication. The arrow shall contrast with the background.

E. Confirmation of button push via latching LED, sound, and vibrotactile bounce.

F. Vibrating tactile arrow shall be able to be adjusted for directional indication.

G. Pedestrian push buttons shall be at least 2 inches in diameter or width, contrast visually with the housing, and require 5 lbf (poundforce) maximum force.

H. The pushbutton assembly shall be die-cast aluminum, powder coated from aluminum alloy 319 or equivalent.

I. The unit shall be fabricated free of voids, pits, dents, molding sand and excessive foundry grinding marks. All design radii shall be smooth and intact. Exterior surface finish shall be smooth and cosmetically acceptable by being free of molding fins, cracks and other exterior blemishes.

J. Assembly color shall be yellow.

K. Mounting bolts shall be brass or stainless steel.

L. Push button unit shall have an actuation indication which will activate upon depression of the push button. If actuation indication is a light then it shall remain on until the next walk cycle.

M. All push button assemblies shall be mounted to the poles by drilling and tapping. Stainless Steel ¼ - 20 bolts shall be used to mount the push button assemblies to poles. Self-tapping screws shall not be used. Stainless steel strapping shall not be allowed.

N. Attached crossing signs shall be 9" x 15" R10-3e, as per the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

O. The back panel portion of the push button assembly shall be designed to accommodate pole diameters from 4" to 14".

2.03 AUDIBLE INDICATIONS

A. A push button locator tone shall sound at each push button.

B. Locator tones should be audible 6 to 12 feet from the push button or to the building line, whichever is less.

C. Locator tones shall have a duration of 0.15 seconds or less, and shall repeat at 1-second intervals.

D. Automatic volume adjustments in response to ambient traffic sound level shall be provided up to a maximum of 89 dB. Locator tone and verbal messages shall be no more than 5 dB louder than ambient sound.

E. All sounds must automatically adjust to ambient noise levels over a 60 dB range.

F. Standard locating tone during Don’t Walk (and clearance if desired) and cuckoo, chirp, or standard voice message during walk.

G. Standard locating tone, custom sound, or verbal countdown during PED clearance.

H. Most sounds can have minimum and maximum volume independently set.

I. Extended button push can turn on, boost, volumes, and/or mute all sounds except those on activated crosswalk.

J. The tone or voice volume, measured at 36 inches from the APS, should be 2dB minimum and 5 dB maximum above the ambient noise.

K. Cuckoo - 1250 Hz and 1000 Hz.

L. Chirp - 2700 Hz and 1700 Hz.

M. Substituting Cuckoo and Chirp sounds with "walk" and "don't walk" audible sounds is optional.

N. Push button locator tone different from cuckoo or chirp.

O. Extended button press which can be used to request a louder WALK signal and locator tone for subsequent clearance interval.

P. System shall allow for independent volume control for locate tones, clearance, and walk tones.

Q. All sounds shall be synchronized to reduce sound clutter.

R. Custom message and sound options definable by customer include:

1. Custom locating tone
2. Informational Message
3. Custom walk sounds/message
4. Custom clearance sound
5. Multiple languages (up to three, selectable by user)
6. Street name in Braille on the sign

2.04 ENVIRONMENTAL REQUIREMENTS

A. The Accessible Pedestrian Push Button Station Assembly (pole unit and central control unit) shall be rated for use in the ambient operating temperature range of -40°C to +65°C (-40°F to +150°F).

B. Push button shall be rated for minimum of 20 million operations with >2 lb. actuation force.

2.05 ELECTRICAL REQUIREMENTS

The Accessible Pedestrian Push Button Station Assembly shall operate over a

voltage range of 95 to 130 VAC, 60 Hz. E. TRANSIENT

2.06 VOLTAGE PROTECTION

The on-board circuitry of a module shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients.

2.07 INPUT PROTECTION

At the point of entry to the module for each input, provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & one on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC- (between the resistor & arrestor).

2.01 POWER FAILURES

Whenever there is a loss of power to the "Walk" or "Don't Walk" for a period greater than 2.0 seconds, the sound shall be deactivated.

PART 3 EXECUTION

3.01 A minimum guarantee for both materials and workmanship shall be provided for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

A. WARRANTY AND GUARANTEES

1. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of thirty-six (36) months. Warranty period shall begin the day the item is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective item. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

2. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee

period. Said work shall be done by manufacturer's representative at no cost to the City.

3. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

4. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

5. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost during guarantee period.

6. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or City's Traffic Engineer's representative, on any special circuitry that may be required in certain applications.

END OF SECTION