Request for Bid
Group 3 Relay Addendum No. 3 to
RFB No. 419770.71.0418
June 21, 2024

The following information encompasses Addendum No. 3 for the above referenced RFB. Bidders shall fully consider and acknowledge this Addendum in the preparation and submittal of its formal Bid. Failure to do so may result in the rejection of the Bid.

Section 1 –Notes and Additional Bidder Questions Received to Date

Section 2 – 00370.3.1 Unit Pricing

Section 3 – Updated Technical Specifications

All other conditions and requirements remain unchanged.

Section 1
Notes and Additional Bidder Questions Received to Date

NOTE: Revised maps cannot be included in this PDF due to file size but are available for viewing and/or downloading on the SARP10 website.

Q1: Project Drawings: Upon reviewing the various grid locations of work, there are various locations where there are obstructions in the way of open cut installation of new piping. Obstructions include power poles, guy wires, fire hydrants, catch basins, structures, fencing, etc. It was noted at the pre-bid meeting that the bid drawings were not designed specific to the work areas in question, rather in a general manner and that each site will be reviewed in the field at the time of work is to be completed, or shortly sometime before. How are Contractors to bid areas of work that include such obstructions noted above? Should we only include sidewalk, curb/gutter, asphalt and landscaping type material removal and replacement in our pricing, per the bid items, with all other removal and replacement being paid on time and material?

SARP10: Items such as these that are encountered and appear to be in conflict with existing alignment will be evaluated and a solution developed with assistance by the Program Team.

Q2: Project Drawings: Various grid locations appear to show piping being replaced in the landscape strip between the back of curb and sidewalk. How should we treat asphalt pavement replacement, when we will be traveling parallel to the roadway and only encroaching into the roadway a partial amount? Details do not show this type of installation example.

SARP10: If there is excavation that occurs in the roadway, the details show that full lane width of restoration is required. Partial lane restoration is not allowed.

Q3: Addendum 2, Question Q5 Response: The question was not answered, as to the amount of flow Contractor's can/should expect for bypass determination- what flows should we expect?

SARP10: See revised bid tab in this addendum. In previous projects, bypass has been used infrequently during construction. An allowance has been included for this line item.

Q4: Addendum 2, Question Q10 Response: The response did not answer the question. What gravel thickness should Contractor's use for determination of bidding purposes, so we are all bidding the same thickness?

SARP10: This unit is per ton and given quantity is without regard of thickness or dimensions for existing gravel drives.

Q5: Addendum 2, Question Q18 Response: For clarity, Contractor's are not to include in their price to raise manholes?

SARP10: Correct, the contractor is not to include a cost to raise manholes.

Q6: Bid Form: The bid items for manholes were reduced to two (2) bid items and a total quantity of two (2) each. The drawings call out a total of eleven (11) manholes to be installed (install= 10 ea., structurally replaced= 1 ea.). If there are 11 ea. to be installed /replaced, why is the total bid quantity only 2 ea.?

SARP10: Bid tab revised to show 10 manholes to be installed.

Q7: Addendum 2, Revised Manhole Rehab. Drawing: The drawing calls out "Install New Manhole (10)", the drawing only shows 9 locations. Should the quantity be 9 or 10 ea.?

SARP10: There are 10 on the drawings. There is one under the M12 label that may be missed.

Q8: General: Does the Owner have a source to dispose of spoils removed from trenches, or have a need for spoil material?

SARP10: Disposal of spoils are the contractors' responsibility. The owner does not have a need for spoil material.

Q9: Addendum 2 Spec. 02530 Revisions: There were significant changes by the addendum, which added various sections to the specifications that are not applicable to the project (i.e. FRP, ductile iron, HDPE pipe, steel casing, inverted siphons, tunneling, boring, jacking, etc.). What is the significance of adding these sections to the specifications?

SARP10: This contract is for installation with PVC material, the other sections are included as to comply with the standard specifications.

Q10: Good Faith Effort Documentation: Will GFE documentation be required to be submitted with our bid, or can it be furnished after the bid?

SARP10: The Good Faith Effort Documentation shall be furnished at time of bid.

Q11: Spec. 00370: Will a Business Interruption/ Disaster Recovery Plan be required to be submitted with our bid?

SARP10: No, a Business Interruption/ Disaster Recovery Plan is not required. If you answer yes, the plan should be submitted. If the answer is No, a plan is not submitted.

Q12: Drawing Grid B3: Should the yellow line tie into manhole FS022665?

SARP10: Yes, see revised maps referenced in the Notes section of this addendum.

Q13: Drawing Grid C6: Should the yellow line tie into manhole WS010307?

SARP10: The yellow line does connect to WS010307. The line from the south dead ends and is a separate line.

Q14: Drawing Grid F3: Should the yellow line tie into manhole FS021312.02?

SARP10: Yes, see revised maps referenced in the Notes section of this addendum.

Q15: Drawing Grid F4: The pipe being replaced between manholes ….619 and 619.01 is under a shed, who's responsible for removing and replacing the structure?

SARP10: Please see revised map for location of this pipe. For bidding purposes, this pipe is in the alley.

Q16: Drawing Grid K15: The line being replaced is not within an alley, rather on the property line between homes. What is the easement width we need to work within and will have access to? What is our access point to this work area from the two streets parallel to this work area?

SARP10: This segment is removed from this scope of work.

Q17: Drawing Grid M11: The pipe being replaced from manhole WS013057 to WS012951, is this the correct alignment, or should it be manhole WS013057 to WS012951.01? If its to manhole WS012951, then the line is crossing private property and appears to be going under homes.

SARP10: Yes, this connects to WS01295.01 and has been revised on maps.

Q18: General: Is tree removal / replacement to be included in our pricing?

SARP10: This item is covered in Specification Section 02630 Site Preparation and Restoration.

Q19: General: Is speed bump removal / replacement to be included in our pricing?

SARP10: Please see revised bid tab. An allowance has been included.

Q20: General: Is pavement striping and markings to be included in our pricing?

SARP10: Please see revised bid tab. This allowance has been included with speed bump replacement in Traffic Calming line item.

Q21: Drawing Grid K15: The 8” line on Grid K15 was deleted on the Pipe Bid Schedule, do bid items 02530-6.03.15.08.03 and 02530-6.04 need to have their quantities adjusted?

SARP10: No, this line will be replaced in scope in kind.

Q22: The Unit Price Bid Form does not include Item/s for Traffic Control. Will the Item/s for Traffic Control be reinstated and measured by Per Crew Day, as it was provided in the previous Group 2 Relay Bid Form?

SARP10: Please see revised bid tab and Specification Section 1551 Traffic Control for Construction Work Zones.

Q23: The Unit Price Bid Form includes Item 02630-4.01 Miscellaneous Site Preparation and Restoration, measured on a Lump Sum basis. Can you please qualify the scope of this item and how it is to be utilized on the Bid Form?

SARP10: This includes Site Preparation and Restoration for work completed in unimproved locations.

Q24: The Unit Price Bid From does not include an Item for Striping. Is Striping to be included under Item 02630-4.01? Can an Item for Striping be added to the Unit Price Bid Form?

SARP10: Please see revised bid tab. This allowance has been included with speed bump replacement in Traffic Calming line item.

Section 2
00370.3.1 Unit Pricing

Table 00370.3.1 - Unit Price Bid Form

Bidder should refer to Section 00270, Instructions to Bidders, when completing this Bid Form. Bidder shall complete this form entirely and return it with Bidder's Bid.

Bid Submitted by: (Company Name)

00370.3 Bid Pricing Information

00370.3.1 Unit Pricing

Bidder proposes to complete the RFB Work based on firm, fixed, unit prices (US dollars), which prices multiplied by the final Work quantities would represent the full consideration to Bidder for its complete and satisfactory performance of the Work in compliance with all the terms and conditions of the RFB Documents. The Unit Prices in this Table include the cost of all the work which is required or implied by the RFB documents or which may be inferred therefrom, and which is customarily provided in furnishing a complete and finished work item of its kind. Further, any and all alterations, modifications, and adjustments to the work item, which is reasonably foreseeable or customarily encountered in providing and installing equipment, material, and services of the work item kind, will be performed without additional compensation.

In the event of a Purchaser-approved change in the scope of Work for which a unit price from this Table is not applicable, as determined by the Purchaser, the Subcontractor shall provide a new unit price for review and acceptance by the Purchaser. Subcontractor shall provide all information requested by the Purchaser to substantiate the value of the new unit price.

00370.3.1.1 Unit Prices Breakdown — **Bidder Response Columns**

Item Number	Item Description	Unit of Measure	Estimated Quantity	Unit Price	Extension Price
71.0418 Group 3 Relay					
Pipe Replacement					
01551-6.01	Traffic Control	Crew Day	550		$ -
02530-6.01	Locate and Expose Mainline Terminus	Each	10		$ -
02530-6.02	Undercut Backfill	Ton	1,500		$ -
02530-6.03.15.08.01	8" Polyvinyl Chloride (PVC) Pipe (0'-6' Depth)	Linear Foot	~~4,285~~ 3,268		$ -
02530-6.03.15.08.02	8" Polyvinyl Chloride (PVC) Pipe (6.1'-10' Depth)	Linear Foot	~~13,130~~ 13,798		$ -
02530-6.03.15.08.03	8" Polyvinyl Chloride (PVC) Pipe (10.1'-14' Depth)	Linear Foot	~~2,250~~ 2,481		$ -
~~02530-6.03.15.10.03~~	~~10" Polyvinyl Chloride (PVC) Pipe (10.1'-14' Depth)~~	~~Linear Foot~~	~~320~~		~~$ -~~
02530-6.03.15.12.01	12" Polyvinyl Chloride (PVC) Pipe (6.1'-10' Depth)	Linear Foot	75		$ -
02530-6.04	Service Lateral Removal and Replacement for Pipe Replacement	Each	~~506~~ 503		$ -
02530-6.05	Pavement Backfill for Pipe Replacement	Cubic Yards	21,108		$ -
02530-6.06	Bypass Pumping Allowance	Lump Sum ~~Each~~	~~61~~ 1	$ 50,000.00	$ 50,000.00
02530-6.08	Hydroexcavating/Hand Digging	Linear Foot	~~20,060~~ 19,622		$ -
Manhole Replacement / Installation					
02531-4.01.A.2	Precast Manhole Replacement ~~(6.1'-10' Depth)~~	Each	1		$ -
02531-4.01.B.1	Precast Manhole Installation ~~(0'-6' Depth)~~	Each	~~1~~ 10		$ -
~~02531-4.01.B.2~~	~~Precast Manhole Installation (6.1'-10' Depth)~~	~~Each~~	~~8~~		~~$ -~~
~~02531-4.01.B.3~~	~~Precast Manhole Installation (10.1'-15' Depth)~~	~~Each~~	~~1~~		~~$ -~~
02531-4.01.C	Pavement Backfill for Manholes	Cubic Yards	60		$ -
Manhole Rehabilitation					
02533-4.01.A	Manhole Rehabilitation - Cementitious Coating	Vertical Foot	36		$ -
02533-4.01.B	Invert and Bench Replacement	Each	1		$ -
Post-Rehabilitation PACP Inspection					
02541-4.01.A	Post Rehab CCTV Inspection ~~(8" diameter)~~ (for all diameters)	Linear Foot	~~19,665~~ 20,060		$ -
~~02541-4.01.A~~	~~Post Rehab CCTV Inspection (10" diameter)~~	~~Linear Foot~~	~~320~~		~~$ -~~
~~02541-4.01.A~~	~~Post Rehab CCTV Inspection (12" diameter)~~	~~Linear Foot~~	~~75~~		~~$ -~~
Post-Rehabilitation MACP Inspection					
02544-4.01.A	GPS Coordinates of Manhole Cover	Each	~~15~~ 128		$ -
02544-4.01.C-1	Post Rehab MACP Level 2 Manhole Inspections	Each	~~15~~ 128		$ -
Site Preparation and Restoration					
02630-4.01	Miscellaneous Site Preperation and Restoration	Lump Sum	1		$ -
Pavement and Incidentals					
02950-4.01.A-1	Asphaltic Concrete Pavement Removal and Replacement	Square Yard	~~15,000~~ 40,875		$ -
02950-4.01.A-2	Concrete Pavement Removal and Replacement	Square Yard	905		$ -
~~02950-4.01.A-3~~	~~Temporary Cold Patch Asphalt Removal and Replacement~~	~~Square Yard~~	~~1,500~~		~~$ -~~
02950-4.01.B	Concrete Sidewalk Removal and Replacement	Square Yard	565		$ -
02950-4.01.C	Concrete Curb and Gutter Removal and Replacement	~~Square Yard~~ Linear Foot	~~6,980~~ 3,000		$ -
02950-4.01.D	Gravel Driveway and Gravel Area Removal and Replacement With Crushed Stone	Ton	17		$ -
	SRF Signs	Each	~~1~~ 2		$ -
02760-5.01	Traffic Calming and Pavement Marking Allowance	Lump Sum	1	$ 15,000.00	$ 15,000.00
	71.0418 Group 3 Relay - Total Estimated Unit Price Value				

Section 3
Updated Technical Specifications

SECTION 01551
TRAFFIC CONTROL FOR CONSTRUCTION WORK ZONES

PART 1 - SCOPE

This work shall consist of furnishing, erecting, illuminating, handling, and maintaining all construction signs (warning, regulatory, and guide), barricades, and other traffic control devices designated for installation at locations specified by the Plans or the approved Traffic Control Plan, or directed or approved by the Purchaser for the purpose of handling traffic safely through construction work zones. This work shall include the provision of flaggers or special measures necessary to assure the handling of traffic safety through construction work zones.

PART 2 - MATERIALS

2.01 GENERAL REQUIREMENTS

A. All signs, barricades, markers, lights, and other traffic control devices for use in construction work zones shall meet the requirements of Part VI of the Tennessee Manual on Uniform Traffic Control Devices (MUTCD). Materials used in the fabrication, construction, and installation of the construction signs, barricades, and other traffic control devices shall conform to the requirements of the MUTCD, and the City of Memphis Standard Construction Specifications.

B. Items are not required to be new. Used items may be acceptable provided the following conditions are met:

1. Units are in good repair, clean, and structurally sound.

2. Reflective sheeting on any unit is clean and in good repair.

3. All legends and messages are sharp, clean, and legible.

4. Reflectivity of said units during the hours of darkness shall provide acceptable, clean and uniform delineation without dead spots.

C. No test reports are required, but the Purchaser will visually inspect all units and accessories for compliance with the various dimensional and material stipulations noted before approving their use in the work. The approval of any unit for use is subject to satisfactory field performance and does not preclude the Purchaser ordering replacements for deteriorated, damaged or otherwise unsatisfactory performance of units; said replacements for these previously approved units shall be without additional compensation.

2.02 SUBMITTALS

1. A Traffic Control Plan shall be submitted to the Program Manager, including the following items:

- Outline of permit acquisition procedure for lane closures.

- Methods for proper signing and barricades, which comply with local requirements and the City.

- Major streets (e.g. Shelby County Principal Arterial & Minor Arterial) requiring a City approved permit if taking a lane for mobile operations, secured through Traffic

Control Plan submittal to the City and signed by a TN P.E. The City requires a two-week lead time for permit processing.

- The Contractor will be required to deliver a sample primary/arterial road Traffic Control Plan for review by the City.
- If the City determines that the nature of the work operation or the type of road in which the Contractor is working requires a permit, the Contractor will be required to modify the sample Traffic Control Plan to obtain a permit from the City.
- For everywhere else where a permit is not required, the Contractor shall develop, provide, and implement a Traffic Control Plan for all mobile operations in accordance with standard MUTCD specifications.
- The Contractor is also responsible for acquiring all necessary disposal and/or landfill site permits required to perform this work.
- Railroad Rights of Way: The Contractor shall notify the Program Manager when work or access to manholes and sanitary sewers lie within the 25 feet railroad easement, as measured by 25 feet outside the nearest rail of the tracks. To access sewer facilities within the 25 feet of the railroad right of way, the Contractor shall contact 48 hours in advance the Program Manager, who will alert the City's Zone Construction Inspector to coordinate individual railroad direction and guidance.

2.03 CHANNELIZING AND WARNING DEVICES

Reflectorization of channelizing and warning devices shall be accomplished using materials meeting the requirements of the City of Memphis Standard Construction Specifications.

A. Traffic Cones.

Traffic cones and tubular markers shall be a minimum of 18 inches in height with a broadened base and shall be made of materials to withstand impact without damage to themselves or to vehicles. Orange shall be the predominant color on cones and tubular markers. For nighttime use they shall be reflectorized or equipped with lighting devices for maximum visibility. The design of traffic cones and tubular markers shall be according to the requirements of Section 6C of the MUTCD.

B. Vertical Panels.

Vertical panels used as channelizing or warning devices shall be 8 to 12 inches in width and a minimum of 24 inches in height. They shall be orange and white striped and reflectorized. The design or vertical panels shall be according to Section 6C of the MUTCD.

C. Drums.

Drums used for traffic warning or channelization shall be approximately 36 inches in height and a minimum of 18 inches in diameter. The markings shall be horizontal, circumferential, orange and white reflectorized stripes meeting the requirements of Section 6C of the MUTCD.

D. Barricades.

A barricade is a portable or fixed device having from one to three rails with alternate orange and white reflectorized stripes used to control traffic by closing, restricting, or delineating all or a portion of the right-of-way. Barricades shall be of one of three types: Type I, Type II, and Type III. The characteristics and design of each type of barricade shall be according to Section 6C of the MUTCD.

E. High Level Warning Devices.

High level warning devices are used to supplement other controls and warning devices and are designed to be seen over the top of preceding vehicles. They shall consist of an orange diamond and three flags. The lowest point of all three flags shall be no less than 8 feet above the roadway. The design shall be according to the requirements of Section 6C of the MUTCD.

F. Warning Lights.

As used herein, warning lights are portable, lens directed, enclosed lights. The color of the light emitted shall be yellow. They may be used either in a steady burn or flashing mode. Warning lights shall be in accordance with the current requirements of ITE Standard for Flashing and Steady Burn Warning Lights (Table 01551-1) and Section 6E of the MUTCD.

TABLE 01551-1
WARNING LIGHTS

	Type A Low Intensity	Type B High Intensity	Type C Steady Burn
Lens Directional Faces	1 or 2	1	1 or 2
Flashing Rate per Minute	55 to 75	55 to 75	Constant
Flash Duration[1]	10%	8%	Constant
Minimum Effective Intensity[2]	4 Candelas	35 Candelas	
Minimum Beam Candle Power[2]			2 Candelas
Hours of Operation	Dusk to Dawn	24 hrs/day	Dusk to Dawn

[1] Length of time that instantaneous intensity is equal to or greater than effective intensity.
[2] These values must be maintained within a solid angle 9^0 on each side of the vertical axis and 5^0 above and 5^0 below the horizontal axis.

PART 3 - CONSTRUCTION REQUIREMENTS

3.01 GENERAL REQUIREMENTS.

A. A Traffic Control Plan shall be developed by the or Subcontractor and approved by the Purchaser before any road, street, or highway, or any section or lane thereof is closed to traffic and construction operations that will for any reason render the roadway generally unsuitable for use of the traveling public are started. Where the Plans and Contract Documents for projects involving roads, streets, and highways do not specify a Traffic Control Plan, and where so required by the Contract Documents, the Subcontractor shall prepare and submit to the Purchaser for approval a Traffic Control Plan for the project which shall include, but not be limited to, signing; application and removal of pavement markings; construction; scheduling; closure of streets or lanes; detours; methods and devices for delineation and channelization; placement and maintenance of devices for delineation and channelization; roadway lighting; traffic regulations; and surveillance and inspection. The Traffic Control Plan shall define in detail the sequence of construction and the proposed number, type, color, size, and placement of construction traffic control devices for each construction phase, all in accordance with Part VI of the Tennessee Manual on uniform Traffic Control Devices for Streets and Highways (MUTCD).

B. The Subcontractor shall designate or otherwise provide personnel to furnish continuous surveillance over his traffic control operations. This designee will also be available at night to

respond to calls involving damage to barricades, lights, signs, and similar items, either through vandalism or traffic accident. The Subcontractor shall make known the name of the person providing the surveillance at the preconstruction conference.

C. All traffic control devices necessary for the first stage of construction shall be properly placed and in operation before any construction is allowed to start. When work of a progressive nature is involved, such as resurfacing a road under traffic, the necessary signs shall be moved concurrently with advancing operation.

D. All construction signs shall be erected such that all supports are vertical, sign panels generally perpendicular to the travelway and legends horizontal so that they effectively convey the intended message. These signs shall be mounted on stationary or temporary supports as directed by the Purchaser and dependent on the type work being performed. In general, work being performed at spot locations and of short duration will necessitate the use of temporary supports properly weighted for stability. If the construction signs are not to be lighted, the supports shall not extend above the top edge of the sign panel.

E. The location, horizontal and vertical placement with respect to the pavement, legends, sheeting, dimensions, and spacing of supports of warning signs, barricades, and other traffic control devices shall be as required by the Plans, the Traffic Control Plan, the MUTCD, and as directed or approved by the Purchaser. The Subcontractor must advise and have the approval of the Purchaser prior to installing or removing traffic control devices from the project.

F. During periods of nonuse, construction signs and other devices shall be removed from the work area, or covered with opaque material, or otherwise positioned so they do not convey their message to the traveling public. If covered, the covering material shall be installed in accordance with the Plans and in such manner that no damage will occur to the sign panel during installation. Covering material shall be maintained in a neat manner during its use.

G. All construction signs, barricades, and other devices which require lighting, as designated by Plans or directed by the Purchaser, shall be provided with warning lights or electric incandescent or fluorescent lighting. It will be the Subcontractor’s responsibility to install electric lighting in a safe manner and in accordance with the latest edition of the National Electrical Code, National Electrical Safety Code, and/or all local codes. The Subcontractor will be responsible for investigating, procuring, and bearing the expense of a continuous power source whether by battery, generator, or commercial A.C. supply.

H. Flaggers with proper attire and flags shall be provided when ordered by the City or Purchaser or when the Subcontractor deems flaggers necessary to safely handle traffic through the construction zone. Flaggers shall wear either an approved uniform or a vest of fluorescent orange color an be equipped with either a red flag of fluorescent material or a paddle with a reflective red and white STOP sign on one side and a reflective orange and black SLOW sign on the other side. Flaggers are considered a general requirement of all traffic control schemes and no direct payment will be made for such.

I. If at any time the City or Purchaser determines that proper provisions for safe traffic control are not being provided or maintained, he may order suspension of the work until the proper level is achieved. In cases of serious or willful disregard for safety of the public or his employees by the Subcontractor, the Purchaser may proceed forthwith to place the traffic control measures in proper condition and deduct the cost thereof from payment due or becoming due the Subcontractor.

3.02 MAINTENANCE

A. The Subcontractor shall assume full responsibility for the continuous and expeditious

maintenance of all construction warning signs, barricades, and other traffic control devices. Maintenance shall include but shall not be limited to replacement of sign panels, barricades, and other devices which in the opinion of the Purchaser are damaged or deteriorated beyond effective use; replacement of broken supports; plumbing of leaning signs; cleaning of dirty signs, barricades, and other devices; repair of defaced signs; and replacement of stolen items.

B. All items used for traffic control shall be generally maintained in its original placement condition and such maintenance will be considered a part of the original installation cost. Failure to maintain all traffic control devices in such manner as to provide adequate continuous safety to the public will be cause for action by the Purchaser as noted in Specification Section 01551 Paragraph 3.01.I.

PART 4 – MEASUREMENT

Each accepted item related to traffic control for construction work zones shall be measured as described herein. All work not described herein shall be considered incidental to the provision of traffic control for construction work zones.

4.01 TRAFFIC CONTROL PLAN.
Development of a Traffic Control Plan for the construction work zone will be paid for on a crew day basis and no measurement will be made.

4.02 TRAFFIC CONTOL DEVICES FOR CONSTRUCTION WORK ZONES.
Furnishing, erecting, and maintaining traffic control devices and other incidentals and personnel required for handling traffic safely through construction work zones will be included in the lump sum payment for Traffic Control Plan and no measurement will be made.

PART 5 – PAYMENT

Payment for accepted work shall be made at the appropriate contract price which shall be payment in full for all work required under the pay item. Payment will be made under the pay items listed at the end of this Specification Section.

5.01 TRAFFIC CONTROL
Payment will be made for the work completed and accepted by the Purchaser at the per crew day price, which shall be full compensation for development of a Traffic Control Plan; for furnishing, erecting, illuminating, handling, and maintaining all construction signs (warning, regulatory, and guide), barricades, and other traffic control devices designated for installation at locations specified by the Plans, the Traffic Control Plan, or directed or approved by the Purchaser for the purpose of handling traffic safety through construction work zones for the duration for the project. Payment shall also include provision for flaggers or special measures necessary to assure the handling of traffic safely through construction work zones.

1.01 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
01551-6.01	TRAFFIC CONTROL	Crew Day

END OF SECTION 01551

SECTION 02530
SEWER PIPE INSTALLATION

PART 1 - SCOPE

1.01 This Work shall consist of the construction of sanitary sewers, siphons, service connections, and/or the removal & replacement of existing sanitary sewers and service connections of the kinds and dimensions shown on the Plans, stipulated in Contract Documents, or as directed by the Purchaser. The construction shall be accomplished by these Specifications and in conformity with the lines, grades, and details shown on the Drawings or established by the Purchaser. The Subcontractor shall perform all work necessary to complete the Contract with the best modern practice. Without specifications that state the quality of any work, the Subcontractor is required to perform such items using first-quality construction. Unless otherwise provided, the Subcontractor shall furnish all material, equipment, tools, labor and incidentals necessary to complete the Work.

PART 2 – MATERIALS AND EQUIPMENT

2.01 MATERIAL

A. Construction Material

1. All material furnished by the Subcontractor shall be new, high quality and free from defects. Previously used material in acceptable condition may be used for bracing, forms, false work, and similar uses. Material not conforming to the requirements of the Specifications shall be considered defective and will be removed immediately from the site.

B. Higher Strength Pipe

1. The Subcontractor may substitute a higher strength pipe of the same type as that specified subject to the approval of the Purchaser.

C. Qualifications of Manufacturers

1. Pipe for sanitary sewers shall be the standard product of an established, reputable manufacturer made in a permanent plant. Suppliers for each material to be used by the Subcontractor shall be subject to approval by the Purchaser. No material shall be delivered until the manufacturer and product have been approved by the Purchaser. For any construction project, pipe and appurtenances for each pipe material shall be the product of a single manufacturer having a minimum of 10 years domestic experience producing the type of pipe supplied.

D. Material Inspection and Testing

1. Representative samples of material intended for incorporation in the work shall be submitted for examination when so specified or requested. All material to be used in the work shall be sampled, inspected, and tested by current ASTM specifications, or other standard specifications approved by the Purchaser. The Subcontractor shall furnish the Purchaser with three copies of certified reports from a reputable testing laboratory showing the results of the tests carried out on representative samples of material to be used on the Project. Each length of pipe delivered to the project shall show the laboratory's stamp. The performance or cost of all testing is the responsibility of the Subcontractor.

2. The Subcontractor shall notify the Purchaser before any deliveries of material and shall

make whatever provisions are necessary to aid the Purchaser in the inspection and culling of the material before installation.

E. Storage

1. The Subcontractor shall provide and maintain storage facilities and exercise such measures to maintain the specified quality and fitness of material to be incorporated in the work. The interior and sealing surfaces of the pipe, fittings, and adapters shall be kept free from dirt and foreign matter. PVC pipe, fittings, and adapters stored outside and exposed to sunlight shall be covered with an opaque material with proper ventilation. All precautions taken to ensure safe storage of materials shall be the responsibility of the Subcontractor.

F. Polyvinyl Chloride (PVC) Gravity Pipe and Fittings (6-15 inch Diameter)

1. All PVC gravity pipe and fittings 6-15 inches in diameter shall be solid wall PVC; no profile wall PVC pipe is allowed for pipes 15 inches or less in diameter. PVC solid wall pipe and fittings for gravity sewer applications shall conform to the requirements of ASTM D 3034. The standard dimension ratio (SDR) shall be SDR 26 (Type PSM). PVC resin shall conform to ASTM D 1784 cell class 12454C. A different cell class shall be allowed only if the material meets the requirements of a superior cell class than 12454C. 6-inch diameter PVC pipe shall only be used for service laterals. Fittings for PVC gravity sewer pipe shall be fabricated from PVC meeting the respective ASTM PVC pipe standard for molded or extruded PVC. The wall thicknesses of the waterway and bell of fittings shall be no less than the respective minimum thicknesses for the equivalent pipe. All fittings shall be compatible with the pipe to which they are attached.

2. All PVC gravity pipe joints shall be gasketed bell and spigot push-on type conforming to ASTM D 3212, unless directed otherwise in these Specifications. Gaskets shall be part of a complete pipe section and purchased as such. Lubricant shall be as recommended by the pipe manufacturer.

G. Polyvinyl Chloride (PVC) Profile Pipe and Fittings (18-36 inch Diameter)

1. All 18-36 inch diameter PVC sewer pipe and fittings shall be designed and manufactured in accordance with ASTM F 679, F 794, F 949, or F 1803. All PVC sewer pipe and fittings shall be manufactured from PVC resin with a cell classification of either 12454C or 12364C as defined in specification ASTM D 1784. The pipe shall be furnished complete with gaskets, fittings, lubricant, etc. as required for proper installation and completion of the line. The minimum pipe stiffness at 5% deflection shall be 46 psi when tested in accordance with ASTM D 2412 and as specified in ASTM F 679, F 794, F 949, or F 1803, as applicable. Samples of the type of pipe to be used shall be tested in accordance with ASTM D 2412. Impact tests shall be conducted in accordance with ASTM D 2444 and shall comply with ASTM F 679, F 794, F 949, or F 1803. Tests shall be conducted by the manufacturer in the presence of the Purchaser's Resident Project Representative, unless otherwise directed by the Purchaser. The Owner and Purchaser will have the right to make unannounced visits to the pipe manufacturer's facility to inspect the manufacturing process.

2. All joints shall be the bell and spigot type and conform to ASTM D 3212. Gaskets shall meet ASTM F 477. All bells shall be formed integrally with the pipe and shall contain a factory installed elastomeric gasket which is positively retained. No solvent cement joints shall be permitted in field construction.

3. The pipe manufacturer shall furnish to the Purchaser a notarized certificate(s) of inspection stating that each piece of pipe used on this project was made and tested in accordance with these specifications.

4. All pipeline material shall be generically the same throughout the project with the permissible exception of utilizing different material for piping used for tie-ins of smaller lines, or as noted on the Drawings or as approved by the Purchaser.

H. Glass Fiber Reinforced Polymer Mortar Pipe and Fittings (up to 72 inch Diameter)

1 Pipe shall meet the requirements of ASTM D 3262 - Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe. The pipe shall be manufactured to form a dense, non-porous, corrosion-resistant, composite pipe that is resistant to corrosion from hydrogen sulfide and other corrosive materials normally found in sewerage systems, all without the use of special HDPE or PVC liners.

2 Minimum acceptable nominal length for joints of pipe shall be 20 feet except where field conditions require otherwise.

3 Design: The design of the pipe shall comply with all requirements of the latest revision of ASTM D - 3262 for non-pressure (gravity) flow conditions. The pipe shall also be designed for a variable depth of cover as shown on the profile; the maximum trench loading that can occur on an empty pipe after backfill is in place; and a live load equal to the AASHTO HS20 loading or the minimum live load as specified in the latest revision of ASTM D - 3262, whichever gives the greater live load.

4 Resin Systems: These shall be only polyester resin systems with a proven history of satisfactory performance in sewage applications. Historical data shall have been acquired from a composite material of similar construction and composition.

5 Glass Reinforcements: Reinforcing glass fibers used in the manufacture of the pipe shall be of the highest quality commercial grade E-glass filaments with binder and sizing compatible with impregnating resins.

6 Interior Lining: All interior surfaces of the pipe shall be lined with a fiberglass reinforced polyester lining as a part of the manufacturing process.

7 Joints: The pipe shall be field connected with fiberglass sleeve couplings that utilize full face elastomeric sealing gaskets of EPDM rubber compound, providing a zero leakage joint. The coupling shall be factory assembled to one end of the pipe. Each joint shall be pressure tested after installation.

8 Tests and Examinations: Tests, in-process and final examinations shall be performed by the manufacturer, or an independent testing laboratory approved by the Engineer, in accordance with the latest revision of ASTM D 3262, in order to assure conformance. All instruments, gauges, and other testing and measuring equipment shall be of the proper range, type and accuracy to verify conformance and test equipment shall be checked at least annually against calibrated and certified test gauges and instruments. The Engineer shall have access to all records of tests and inspections related to the manufacture of the pipe, and, without notice to the manufacturer, shall also have the right to witness the manufacture of the pipe and any tests being performed by the manufacturer or his suppliers relative to products, materials, or the pipe being produced. Copies of records of tests and inspections shall be submitted if requested by the Engineer.

   a. Pipes: These shall be manufactured and tested in accordance with ASTM D 3262.
   b. Joints: Coupling joints shall meet the requirements of ASTM D 4161 and/or produce a zero leakage joint.
   c. Stiffness: Minimum pipe stiffness when tested in accordance with ASTM D 2412 shall be 46 psi.

9. Fittings and Special Pipe: Fittings shall be contact molded or manufactured from mitered sections of pipe joined by glass-fiber-reinforced overlays, all capable of withstanding all operating conditions when installed.

10. Curves of long radius shall be formed by the use of bevel end pipe or by the use of bevel adapters. Deflection of pipe joints to form the long radius curves will not be accepted. Special pipes shall be designed to provide the same strength as the

adjacent pipe. Branch connections or openings, such as manholes and bypass pumping connections, shall be incorporated in straight pipe and shall be suitably reinforced. Special pipes shall be provided with joints corresponding to those on adjoining straight pipes. Special ends shall be provided on pipe, where required, to connect to pipe of other manufacturers and special structures.

11. Unloading Handling and Storage: All pipe shall be inspected at time of delivery, and damaged pieces rejected and removed from the site of the work. Unloading shall be done by mechanical equipment designed to properly handle the pipe, and dropping from delivery vehicles will not be permitted. Pipe shall be stored in an orderly manner to protect the pipe from injury, and from damage by freezing, all in accordance with the manufacturer's written instructions.

I. Ductile Iron

1 Ductile iron pipe for gravity sewer and service connections will conform to ASTM A 746. Ductile iron pipe for force main applications will conform to ANSI A 21.51. The pipe thickness design will conform to ANSI A 21.50. If no thickness class is specified on the Plans or Contract Documents, Class 50 or approved equivalent will be used. All ductile iron pipe will be lined with either Protecto 401 Ceramic Epoxy, SewPer Coat Cement Mortar Lining, or Polyethylene. Linings will be applied according to manufacturer's recommendations. Fittings will conform to the requirements of ANSI A 21.10. Unless otherwise specified, joints will be push-on gasket type conforming to the requirements of ANSI A 21.11. Mechanical joints will conform to the requirements of ANSI A 21.11. Flanged joints will conform to the requirements of ANSI A 21.15. Flexible joint ductile iron pipe for river crossing applications will conform to ASTM A 536 and will be Grade 70-50-05. Steel retainer rings will conform to ASTM A 148 for Grade 90-60.

J. Adapters and Couplings

1. At the direction of the Purchaser, a connection of sanitary sewer pipes, 8 inches through 16 inches, of dissimilar material, different sizes or for the repair of sanitary sewer pipes of similar material may be made by means of an approved compression or mechanical connector or adapter. The gaskets for compression connectors or adapters shall be manufactured of an approved preformed elastomeric material conforming to applicable sections of ASTM Standards C 143, C 425, C 564, and D 3212. Mechanical couplings or adapters shall have tightening clamps or devices made of 300 series stainless steel with a stainless steel shear ring and stainless steel hardware, as specified in ASTM A 167. If a stainless steel shear band is not used, a concrete collar shall be required. Each connector and adapter shall bear the manufacturer's name and required markings. Installation shall be by the manufacturer's recommendations.

2. At the direction of the Purchaser, a connection of sanitary sewer pipes (18 inches in diameter and larger) of dissimilar material, different sizes or for the repair of sanitary sewer pipes of similar material may be made in accordance with this Specification. Mechanical connectors meeting the above requirements may be used at the direction of the Purchaser.

K. Crushed Limestone

1. Crushed limestone shall be size No. 67 Coarse Aggregate meeting the requirements of the Tennessee DOT Standard Specifications for Road and Bridge Construction and the following gradation:

Total Percent by Dry Weight,

	Passing Each Sieve (U.S. Standard)				
Size No.	1"	3/4"	3/8"	No. 4	No. 8
67	100	90-100	20-55	0-10	0-5

L. Pit Run Gravel

1. Pit run gravel shall consist of one of the three gradations shown in the table below.

	Total Percent by Dry Weight, Passing Each Sieve (U.S. Standard)						
Size No.	2½"	2"	1½"	1"	3/8"	No.40	Clay *
1	100	95-100			35-65	10-30	1-12
2		100	95-100		40-65	10-30	1-12
3			100	90-100	45-65	10-35	2-12

*Clay content shall be determined by the Hydrometer Test - AASHTO T 88. Clay content up to 15 percent may be used with the approval of the Purchaser.

2. The portion passing the No. 40 sieve shall be known as the binder. The binder aggregate shall consist of hard durable particles of limestone or sound siliceous material. Shale

aggregate or pipe clay binder shall not be acceptable. The percent of silt shall not exceed the percent of clay by more than 25 percent. If the binder material is insufficient to bond the aggregate a satisfactory binding material may be incorporated, as approved by the Purchaser, so that the resultant mixture shall comply with these Specifications. The mixing shall be done uniformly, and blending of material on stockpiles or in the pits by bulldozers, clamshells, draglines, or similar equipment shall not be permitted.

M. Non-Shrinking Grout

a. Grout shall be mixed in small quantities as needed and shall not be re-tempered or used after it has begun to set. Unless otherwise specified, the grout shall consist of one part Portland cement, two parts masonry sand by volume, a non-shrinking, nonmetallic admixture and sufficient water to form a grout of proper consistency. When non-shrinking or non-shrinking fast setting grout is specified it shall be formulated by the incorporation of an admixture, or a premixed grout may be used.

N. High Density Polyethylene (HDPE) Pipe and Fittings

a. High Density Polyethylene Pipe (HDPE) may be used in construction of inverted siphons. No HDPE will be allowed in any other gravity sewer application. All HDPE shall be manufactured from virgin, extra high molecular weight, high density PE3408 or PE3608 polyethylene pipe grade resin to a minimum cell classification of PE345434C as determined by ASTM D3350. No post-consumer recycled polyethylene materials shall be allowed. The minimum material classification shall conform to III C 5 P34 as determined by ASTM D1248.

b. All HDPE pipe and fittings shall conform to ASTM F714 and ASTM D3261,

respectively, and have a Standard Dimension Ratio (SDR) of 17, maximum.

c. Successive joints of HDPE pipe shall be joined by heat fusion at a fusion pressure of 75 psi and temperature of 400° F. All such connections shall be performed in strict accordance with the manufacturer's instructions.

O. Steel Casing Pipe

1. Casing pipe will conform to ASTM A 139. Minimum yield strength will be 35,000 psi. Wall thickness will meet the requirements of the latest revision of the American Railway Engineering Association Manual of Recommended Practice unless otherwise specified. Wall thickness will be:

Nominal Thickness Inches	Nominal Diameter Inches
0.188	Less than 14
0.219	14 and 16
0.250	18
0.281	20
0.312	22
0.344	24
0.375	26
0.406	28 and 30
0.438	32
0.469	34 and 36
0.500	38, 40, and 42

2. When casing is installed without a protective coating and is not cathodically protected, the wall thickness shown above will be increased to the nearest standard size that is a minimum of 0.063 inches greater than the thickness shown. This requirement does not apply to casing diameters less than 12 3/4 inches.

2.02 EQUIPMENT

A. The Subcontractor shall furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work. All equipment and facilities shall be on site and approved by the Purchaser before work will be permitted to begin.

PART 3 - CONSTRUCTION REQUIREMENTS

3.01 EXCAVATION

A. All excavation performed under this Section including trench excavation, structure excavation, and channel excavation, but excluding undercut excavation, shall be considered unclassified excavation despite the nature of the material and objects excavated and shall not be measured or paid for separately except as specifically noted. Pavement removal and replacement shall be accomplished as specified in Specification Section 02950.

B. Trench Excavation

1. All trenches shall be open cut unless otherwise shown on the Drawings. Tunneling, boring, or jacking may be allowed by written permission of the Purchaser.

2. Trenches may be excavated by machinery to a depth that will not disturb the finished

subgrade. The remaining material shall be hand excavated so that the pipe is bedded on a firm, undisturbed subgrade.

3. No more than 300 feet of trench shall be opened ahead of the completed sanitary sewer, nor will more than 100 feet be left unfilled except by written permission from the Purchaser. In special cases, the Purchaser may limit the distance to which the trench may be opened by notifying the Subcontractor in writing.

4. The width of trenches below a level 1 foot above the outside top of pipe shall be at least 6 inches but not more than 12 inches on each side of the outside of the pipe for all sizes up to and including 16 inches in diameter. A maximum trench width dimension for these pipe sizes shall be 42 inches. For 18-inch diameter pipes, the width of trenches below a level 1 foot above the outside top of pipes shall be at least 6 inches on each side of the pipe, with a maximum trench width of 42 inches. For pipe sizes more than 18 inches, the width of trenches below a level 1 foot above the outside top of the pipe shall be at least 12 inches but no more than 15 inches on each side of the outside of the pipe. If the trench width at or below 1 foot above the top of pipe exceeds the width specified, provisions shall be made at the Subcontractor's expense to compensate for the additional load upon the pipe.

5. The sides of the trench shall be as nearly vertical as possible. The bottom of the trench shall be carefully graded, formed, and aligned according to SARP10 *Trench Cross Section Showing Terminology* Figure and to the satisfaction of the Purchaser before sanitary sewers are laid.

C. Other Excavation

1. Undercut Excavation: Undercut excavation shall consist of removing and disposing of unsatisfactory material below the grade established on the Drawings for sanitary sewers, structures, and manholes. No undercut excavation shall be done without prior authorization of the Purchaser. The limits of undercut excavation shall be determined by the Purchaser’s Resident Project Representative who will be present during the undercut operations.

2. Undercut areas shall be backfilled with No. 67 limestone or other aggregate approved by the Purchaser to the grade established on the Drawings to produce a suitable foundation. The backfill shall be placed in 6 inch maximum lifts and compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698) or a minimum relative density of 0.75.

3. Unauthorized Excavation Below Subgrade or Outside Limits: Any unauthorized excavation and subsequent removal and backfilling beyond the lines and grades shown on the Drawings shall be at the Subcontractor’s expense. The excess space between the undisturbed bottom and sides of the excavation and subgrade limits shown on the Drawings shall be backfilled according to this Specification.

D. Change in Location and Grade

1. If the Purchaser orders in writing that the location or grade of a proposed sanitary sewer facility be changed from that shown on the Drawings, the following provisions will apply. If the change is made before excavation work has begun and the item being constructed is covered in the Proposal Sheet(s) by pay items with appropriate depth classifications, the appropriate pay item will apply. If the facility being constructed is not covered in the

Proposal Sheet(s) and if the average excavation per linear foot at the changed location or grade is within 10 percent of the original Plan quantity, there will be no change in the unit price for this work. If the average excavation per linear foot at the changed location varies more than 10 percent above or below original Plan quantities, a Contract Revision will be prepared to cover the new work. For purposes of comparing changed quantities with Plan quantities, a 1 foot long strip will be calculated from natural ground line to invert along both the revised and original locations. These calculations will then be multiplied by the proper lengths to determine the total cost.

2. If the change is made after excavation has already begun on the original Plan location, the procedures described above shall apply to payment for work along the changed location. If abandonment of an existing excavation is required due to a change by the Purchaser, a Contract Revision shall be prepared covering the backfilling and restoration of the abandoned excavation. Backfilling and restoration of the abandoned excavation shall be accomplished according to the appropriate section of these Specifications.

3. Filling a portion of existing excavation to meet changed grades shall be accomplished in accordance with this Specification.

4. If a change in a location and/or grade is authorized in writing by the Purchaser at the written request of the Subcontractor, the Subcontractor shall not receive any additional compensation for the changed work. Backfilling and restoration of abandoned excavation work shall be accomplished totally at the Subcontractor's expense. If changes requested by the Subcontractor result in reduced lengths and/or depth of excavation, the revised quantities using Proposal unit prices or Contract Revisions as appropriate shall be used to develop payment.

E. Disposition of Excavated Material

1. Excavated material suitable for backfill shall be stored no closer than 2 feet from the edge of the excavation. Excavated material shall not obstruct crosswalks, sidewalks, driveways, street intersections, nor interfere unreasonably with travel on streets. Gutters or other surface drainage facilities shall not be obstructed. The Subcontractor must provide access to fire hydrants, mailboxes, sewer and conduit manholes, and similar utility or municipal service facility as required. Excavated material intended for backfill shall be stored in a way that minimizes loss of excavated material due to erosion. The Subcontractor shall comply with all applicable OSHA regulations and City of Memphis Storm Water Ordinances.

2. Unless otherwise directed, all excavated material that will not be used for backfilling or restoration shall be removed from the site and disposed of by the Subcontractor. If the Subcontractor proposes to store or place such excess excavated material upon any private property, written consent of the property owner or owners must be obtained by the Subcontractor in advance. A certified copy shall be given to the Purchaser. No surplus or excess material shall be deposited in any stream channel nor anywhere that would change preconstruction surface drainage.

F. Control of Water

1. The Subcontractor shall keep all excavations free of water. If the trench subgrade consists of good soil in good condition at the time of excavation, it shall be the Subcontractor's responsibility to maintain it in suitable condition. Dams, flumes, channels, sumps, or other work and equipment necessary to keep the excavation clear of water shall be provided by the Subcontractor. Dewatering of trenches shall

be incidental to trench excavation. The Subcontractor shall avoid producing mud in the trench bottom by

his operations. If necessary or so ordered by the Purchaser, the Subcontractor shall remove any soil that becomes unacceptable and replace it with limestone or other approved aggregate at his own expense to maintain a firm, dry base.

2. Pipe embedment, laying, jointing, and the placing of concrete or masonry shall be done in a water free trench or excavation. Trenches shall be kept clear of water until pipe joints, concrete and masonry have set and are resistant to water damage. The water shall be disposed of in a manner acceptable to the Purchaser.

3. All gutters, pipes, drains, conduits, culverts, catch basins, storm water inlets, ditches, creeks, and other storm water facilities shall be kept in operation, or their flows shall be satisfactorily diverted and provided for during construction. Any facilities disturbed during construction shall be restored to the satisfaction of the Purchaser.

G. Excavation Around Obstructions

1. The Subcontractor shall cautiously excavate to find the limits of underground obstructions anticipated within the excavation. When a water pipe, gas pipe, other sanitary sewer, storm drain, or similar utility comes within the limits of the trench, such facilities will be properly supported.

2. The Subcontractor shall perform all excavation by hand where excavation machinery would endanger trees, structures, or utilities that otherwise might be saved by hand excavation.

3. Hydroexcavation/Hand Digging

   a. The Subcontractor, in order to protect existing utilities, shall cautiously hydroexcavate or hand excavate the entire perimeter of the excavation to a minimum depth of four feet to locate all underground obstructions within the excavation. The excavation method to be utilized on any given repair (hydroexcavation or hand digging) is at the Subcontractor's discretion. When a water pipe, gas pipe, other sanitary sewer, storm drain, or similar utility comes within the limits of the trench, such facilities shall be properly supported.

H. Excavation for Manholes and Special Structures

1. The Subcontractor shall be responsible for performing the Work according to the lines and elevations shown on the Drawings or as directed by the Purchaser. The Subcontractor shall excavate as required for all structures with foundations carried to firm, undisturbed earth at the elevation of the underside of the structure.

2. The outside dimensions of excavations for manholes and special structure shall be at least 12 inches greater than the outside of the masonry or concrete work to permit backfilling around the structure.

3. Where structures are to be built in street rights-of-way or paved areas, the excavation shall not exceed 2 feet from the outside of the masonry or concrete work. If the excavation exceeds this limit, the Subcontractor shall be required to backfill the entire space around the structure with pit run gravel compacted as specified in this Specification.

I. Special Protection

1. Treacherous Ground: When running sand, quicksand, or other treacherous ground is encountered, the work shall be carried on with the utmost urgency and shall continue day and night should the Purchaser so direct.

2. Sheeting and Shoring: The Subcontractor shall furnish, place, and maintain sheeting and shoring as required to support the sides of any excavation to prevent earth movement that could endanger the workers or public and to prevent damage to the excavation, adjacent utilities or property. The Subcontractor shall place this sheeting and shoring without the Purchaser's instructions.

3. Sheeting shall extend below structure invert a sufficient depth to assure adequate support. In the installation of sheeting, the use of vibratory type pile drivers (as opposed to impact type) shall be limited to sheeting driven no greater than 5 feet below the invert. The sheeted trench width, as measured between those faces of the sheeting in contact with the earth trench wall, shall not exceed the maximum width of a trench. Walers and struts shall be designed and installed to present no obstructions to proper placement of the pipe, pipe embedment, cradle or encasement, and they shall not interfere with the satisfactory installation of the pipe.

4. Sheeting, bracing, and shoring shall be withdrawn and removed as the backfilling is being done, except where the Purchaser permits the material to be left in place. The Subcontractor shall cut off sheeting left in place at least 2 feet below the surface and shall remove the cut off material from the excavation.

5. All sheeting, bracing, and shoring which is not left in place under this provision shall be removed in a way that will not endanger the completed work or other structures, utilities, storm drains, sewers, or property. The Subcontractor shall be careful to prevent the opening of voids during the extraction process.

6. If sheeting and shoring are not specifically required on the Drawings or in the Specifications, steel drag shields or trench boxes may be used subject to the authorization of the Purchaser. Voids left by the advancement of the shield shall be carefully backfilled and compacted following trench backfill requirements.

7. Excess Width of Trench: If the Subcontractor is permitted to use equipment that results in wider trenches than specified, approved methods shall be used around the pipe to resist the additional load caused by the extra width. The dimensions of the cradle or other methods will be specified by the Purchaser. The Subcontractor shall be responsible for meeting all applicable OSHA requirements. No extra compensation will be allowed for the additional material or work. Excess width trenches for semi-rigid and flexible pipe shall be backfilled and compacted according to ASTM D 2321, and no concrete cradle shall be used.

8. Underpinning: When excavations require underpinning of existing structures, the Subcontractor shall submit shop drawings of underpinning details to the Purchaser for review before commencement of excavation below the foundation of the structure. Review of underpinning details by the Purchaser shall not relieve the Subcontractor of his responsibility for protection of the structure and its contents.

J. Existing Utilities

1. It shall be the Subcontractor's responsibility to arrange for the location of existing utilities prior to excavation. The Subcontractor will also be responsible for

coordinating the relocation of any existing utilities with the appropriate utility owner.

2. Protection: The Subcontractor shall protect any storm drain, sewer, or utility within the limits of the construction. The Subcontractor shall proceed with caution and shall use every means to establish the exact location of underground structures and facilities before excavating in the vicinity. The Purchaser shall not be responsible for the cost of protection or repair or replacement of any structure, pipe line, conduit, service connection, or similar facility broken or damaged by the Subcontractor's operations. All water and gas pipes and other conduits near or crossing the excavation shall be properly supported and protected by the Subcontractor.

3. If the construction requires the removal and replacement of any overhead wires or poles, underground pipes, conduits, structures or other facilities, the Subcontractor shall arrange for such work with the Owner or Owners of the facilities. No additional payment will be made by the Purchaser for this work.

4. Service Connections: Sewer and utility services between mains and buildings shall be maintained and adjusted as necessary by the Subcontractor to provide as nearly a continuous operation as can be expected. This shall be accomplished in any way that the Subcontractor chooses, provided the individual service is not interrupted for more than two consecutive hours. The occupants shall be notified by the Subcontractor at least six hours before such service interruptions. When a break occurs, the Subcontractor shall notify the affected occupant(s) of the probable length of time that the service will be interrupted. New service laterals with double-sweep cleanouts will be required to be installed to the property line for each service and reconnected to the existing service if one exists. If no service exists, the Subcontractor shall cap the pipe after installing a cleanout.

5. If existing underground facilities or utilities require removal and replacement for the performance of this work, all replacements shall be made with new material conforming to the requirements of these Specifications. If not specified, the material will be as approved by the Owner.

6. The removal and replacement of water services to adapt to new construction shall be the Subcontractor's responsibility within the limits where the new service line grade blends smoothly with the existing service line grade.

8. The Subcontractor shall be responsible for any damage to the sewer house connection because of his operations. The Purchaser does not guarantee the number, size, condition, nor length of adjustment necessary to bring a service to a new grade.

3.02 SEWER PIPE INSTALLATION

A. General

1. Sewer pipe and pipe embedment shall be constructed as shown on the Drawings. It shall be the Subcontractor's responsibility to find all underground utilities before construction to ensure there are no conflicts with the proposed line and grade. The Subcontractor’s surveyor shall verify the base information on the Drawings prior to commencement of construction. Any discrepancies in the Drawings shall be reported to the Purchaser immediately. If approved by the Purchaser, minor changes in the alignment or grade will be permitted to avoid underground facilities, if straight alignment can be maintained between manholes. If minor changes in line or grade cannot avoid a conflict with the existing utility, the Subcontractor shall arrange with the owner of said utility to have it adjusted as required to accommodate the proposed

sewer at no additional expense to the Purchaser.

B. Modifications of Existing Sanitary Sewer Facilities

1. Maintenance of Flow: Where existing sewer lines are being modified, the Subcontractor shall arrange his work so that sewage flow will be maintained during the construction period with no discharge of sewage into the open trench, and no back up of sewage in the existing line. The Subcontractor shall provide necessary bypass pumping capacity to carry flow downstream of the section to be modified.

2. Abandonment of Sewer Pipe: Sewer pipe called for in the Specifications or Drawings to be abandoned shall be sealed at each end for a minimum distance of 18 inches, or one-half the diameter of the pipe, whichever is greater. Unless otherwise specified, the pipe shall be sealed with a brick bulkhead and/or acceptable cement grout to form a solid watertight plug completely bonded to the pipe.

3. The Subcontractor shall be allowed to remove pipe to be abandoned if wanted. If the Subcontractor elects the removal method, all associated costs shall be included in the cost for other Pay items.

4. Connection to Existing Manholes: The Subcontractor shall cut suitable openings into existing manholes or remove existing pipe to accommodate the sewer pipe at the proper elevation, location, and direction, as indicated on the Drawings. Care shall be used to avoid unnecessary damage to the existing manhole.

5. All loose material shall be removed from the cut surfaces that will be completely coated with non-shrinking grout before setting the pipe. Before inserting the pipe, a sufficient thickness of grout shall be placed at the bottom and sides of the opening for proper bedding of the pipe. For semi-rigid and flexible pipe installations a water stop as approved by the pipe supplier shall be installed on the pipe according to the manufacturer's recommendations. After setting, all spaces around the pipe shall be solidly filled with non-shrinking grout and neatly pointed up on the inside to present a smooth joint, flush with the inner wall surface. Any necessary revisions on the existing manhole invert shall be made to provide a smooth, plastered surface for properly channeled sewage flow from the new connection. Plaster on the exterior of brick manholes shall be repaired with non-shrinking grout. Particular care shall be given to insure that the earth sub-base and bedding next to the manhole will provide firm solid support to the pipe.

6. Removal of Sewer Pipe: Existing pipes and manholes to be removed and their locations shall be shown on the Drawings. Existing sewer pipe and manholes that must be removed to excavate for the proposed sewer shall be included in the cost of the proposed sewer pipe and no additional compensation shall be made to the Subcontractor. The City reserves the right to retain or reject salvage of any material encountered. All remaining material becomes the property of the Subcontractor who shall be responsible for properly disposing of the same.

3.03 PIPE EMBEDMENT

A. Pipe embedment will be defined as that material supporting, surrounding and extending to 6 inches above the top of the pipe. Pipe Embedment for sewer pipe shall conform to the requirements given below. At the direction of the Purchaser or as shown on the Drawings, sewer pipe and backfill shall be encapsulated in geotextile fabric meeting the following requirements:

Physical Property	Test Method	Acceptable Test Result
Tensile Strength, wet, lbs.	ASTM D-1682	200 (min)
Elongation, wet, %	ASTM D-1682	40 (min)
Coefficient of Water Permeability, cm/sec	Constant Head	0.03 (min)
Puncture Strength, lbs.	ASTM D-751	100 (min)
Pore Size - EOS U.S. Standard Sieve	Corps of Engineers CW-02215	40 (max)

B. Crushed Limestone

1. Pipe embedment material shall be Number 67 crushed limestone. Pipe 8 inches to 24 inches in diameter shall be bedded on 4-inches of Number 67 crushed limestone. Pipe 27 inches to 48 inches in diameter shall be bedded on 6-inches of bedding material. Pipe embedment for pipes larger than 48 inches in diameter shall be by design based on anticipated soil conditions. After pipe installation, crushed limestone shall then be tamped under the haunches and continued in layers not more than 6 inches in loose thickness around and above the pipe to a level 6 inches above the outside top of the pipe. The remainder of the installation shall be as outlined in this Specification's Backfill requirements.

3.04 PIPE LAYING

A. Inspection Before Laying

1. All pipe shall be inspected upon delivery. Pipe that does not conform to the requirements of these Specifications or is not suitable for use will be rejected by the Purchaser and immediately removed from the work site.

B. Preparation of Pipe Ends

1. All surfaces of the pipe to be joined shall be clean and dry. All necessary lubricants, primer, adhesives, and similar material shall be used as recommended by the pipe or joint manufacturer's specifications.

C. Care During Hoisting, Placing, And Shoving Home

1. Equipment used to handle, lay, and join pipe shall be equipped and used as to prevent damage to the pipe. All pipe and fittings shall be carefully handled and lowered into the trench. Damaged pipe or jointing material shall not be installed.

D. Direction of Work

1. The laying of pipe shall be commenced at the lowest point. The bell or grooved end shall be laid upgrade. All pipe shall be laid with ends abutting and true to line and grade. The pipe ends shall be carefully centered so that when laid they will form a sewer with a uniform invert.

E. Uniform Pipe Bearing

1. Special care shall be taken to insure that the pipe is solidly and uniformly bedded, cradled, or encased according to the Drawings. For pipe with a bell that is larger than the barrel of the pipe, the bedding material shall be removed to a depth that will provide continuous support for the bell and barrel. No pipe shall be brought into

position for joining until the preceding length has been bedded, joined, and secured in place. Where a concrete cradle is required, the pipe shall be supported at no more than two places with masonry supports of minimum size sufficient to provide the required clearance and to prevent displacement during placing of concrete.

F. Alignment and Grade

1. Each piece of pipe shall be checked for vertical and horizontal alignment immediately after being laid. All adjustments to alignment and grade must be made by scraping away or filling in under the barrel of the pipe and not by wedging or blocking up any portion of the pipe or striking the pipe to drive it down. Curved alignments shall not be allowed except as directed by the Purchaser.

G. Backfilling to Secure Pipe

1. When the joint is made, sufficient backfill material shall be simultaneously placed along each side of the pipe to prevent moving the pipe off line and grade. Particular care shall be used to prevent disturbance or damage to the pipe and the joints during backfilling.

H. Flotation and Water in the Trench

1. The Subcontractor shall take all necessary precautions to prevent flotation of the pipe in the trench. Water shall not be allowed to rise in the trench. The Subcontractor shall use well points, sump pumps, or another approved method of dewatering as required to lower the water table below the bottom of the excavation while minimizing the migration of fines from the surrounding area. The Subcontractor shall make a request to the Purchaser and receive approval prior to the use of special dewatering equipment other than well points or sump pumps. Dewatering operations are considered incidental to the work and no additional compensation will be made to the Subcontractor.

I. Open Ends

1. Whenever pipe laying is stopped for any significant length of time, such as at the end of a workday, the unfinished end shall be protected from damage and a temporary tight fitting plug or bulkhead shall be placed in the exposed ends of the pipe to keep soil or other debris from entering the pipe.

J. Concrete Cradle Section next to Manhole

1. The pipe shall be supported from the manhole wall to the limits of the manhole excavation in a normal sewer trench with a concrete cradle, structurally continuous with the manhole base slab or footing. Cost for this work is incidental to the cost of the pipe installation.

K. Cutting Pipe

1. Cutting shall be in a neat workmanlike manner at right angles to the pipe axis without damage to the pipe. The Subcontractor shall smooth the cut end by power grinding or filing to remove burrs and sharp edges.

L. Wyes and Special Fittings

1. Wyes, stubs, reducers, fittings, or other special pipes shall be installed as shown on the Drawings or where ordered by the Purchaser. The fittings and special pipes shall

be made of a compatible material, type, and class and/or strength designation as the pipe and installed as required by the Drawings and Specifications. The cost for providing and installing the above items is incidental to the cost of the pipes.

3.05 PIPE JOINTS

A. General

1. Pipe shall be jointed immediately following the laying of each section. No pipe section shall be left overnight which has not been completely jointed to the preceding pipe section in conformance with these Specifications.

2. The following provisions will apply to insure tight and sound joints:

   a. The joint will be placed with special care to avoid breaking joints and to leave gasket, if required, in proper position.
   b. All pipe 12 inches in diameter or larger will have dead weight held by crane while being lined up and pushed home.
   c. Pipe will be pushed home with a constant and even force and not jarred home by the momentum of a moving force that will place an impact load on pipe.
   d. Cement and lubricant will be used as recommended by the manufacturer and designated by the Purchaser.

B. Compression Joints

1. The two ends to be joined shall be thoroughly cleaned and a compression gasket compatible with the type of pipe to be joined shall be at the position recommended by the pipe manufacturer.

2. Lubricant recommended by the gasket manufacturer shall be liberally applied to the gasket and both ends immediately before pipe ends are joined. The upstream pipe shall be positioned such that the spigot may enter the bell squarely. The pipe being laid shall be pushed home and the gasket position checked with a feeler gauge before installation of the next section. Flat, unconfined gaskets on concrete pipe shall be cemented to the spigot at the position recommended by the pipe manufacturer.

C. Mechanical Joints

1. The two ends to be joined shall be thoroughly cleaned with a wire brush and the plain end, socket end, and gasket shall be brushed with soapy water. The end shall be centered in the socket and adequate anchorage shall be provided to hold the pipe in position until the joint can be completed. When deflecting pipe from a straight line is necessary, the deflection shall be made after joint assembly and before tightening bolts. Pipe deflection shall not exceed that specified by ANSI C 600.

2. When tightening bolts, it is essential that the gland be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. All bolts shall be torqued to the required range recommended by the pipe manufacturer. The Subcontractor shall avoid over stressing the bolts. Gauge lines on the spigot end shall be checked following assembly to ensure proper positioning of bell and spigot has been accomplished.

3. Any joints not properly positioned shall be disassembled, cleaned, and reassembled as previously indicated.

D. Flanged Joints

1. The two ends to be joined shall be thoroughly cleaned with a wire brush. Bolt holes on each pipe flange to be joined shall be aligned and bolts inserted. Bolts shall be torqued evenly by alternating tightening of bolts opposite one another until all bolts are torqued to the recommended pressure.

F. Restrained Joints

1. Restrained push-on joints are to be used as specified on the Drawings or by the Purchaser. These special joints shall be installed as specified by the manufacturer. The length of the pipe to be restrained will be determined by the Purchaser based on pipe size, internal pressure, depth of cover, and soil characteristics around the pipe.

3.06 SERVICE CONNECTIONS

A. The Subcontractor shall install a new lateral with cleanout for each house connection. Cleanouts should be located on the property line or easement with 6-inch PVC (SDR 26) with a minimum slope of 1 percent unless otherwise directed by the Purchaser.

B. The Subcontractor shall provide a Double Sweep PVC cleanout with a PVC screw plug cap and 4-inch PVC stack pipe. When installed, the cap shall lie 3-inches below finished grade.

C. If the existing service connection is 4-inch diameter, the Subcontractor shall provide a 6-inch to 4-inch concentric PVC reducer to connect the new 6-inch lateral to an existing 4-inch private property lateral.

D. The Subcontractor shall connect the new lateral to the PVC main with a PVC fitting in accordance with the details shown on *Typical Installation of Service Lateral*.

3.07 PIPE CAPS AND PLUGS

A. Wyes, stubs, or other fittings installed in the pipe for future connections shall be closed at the open end. For pipes 21 inches in diameter or smaller, an approved cap or plug shall be installed in the bell or socket using the same type joint or jointing material as required for the sewer. For pipes larger than 21 inches in diameter, temporary approved masonry bulkheads of the thickness required by the Drawings and Specifications to close the open end may be substituted for stoppers. Care in backfilling shall be used so that such closure and its seal will not be disturbed. This stopper shall be jointed so that it may be removed later without injury to the pipe itself. Work and material is incidental to the cost of the pipe installation.

3.08 INVERTED SIPHONS

A. Each siphon will include inlet, outlet, and any intermediate manholes where shown on the Plans with all foundations, pipes, and pipe encasement and other appurtenances. Pipe to be included in the cost of the siphon is to be all pipe, fittings and specials between the center of the inlet manhole and the center of the outlet manhole.

B. The Contractor will construct cofferdams, temporary bulkheads, perform all pumping and other work necessary to protect the siphon during construction. The Contractor will be required to maintain a dry trench during construction, and will never be permitted to lay pipe or place concrete with water in the trench. Trenches will be kept free from water until the material in the joints and masonry has sufficiently hardened.

C. Unless otherwise specified, inverted siphon pipe will be HDPE conforming to Specification Section 02530 Paragraph 2.01.N. The siphon pipes will be encased in concrete at the locations and to the dimensions shown on the Plans or Design Standards. The excavation, bedding, laying, jointing, pipe encasement, and backfill operations will conform to the applicable sections of this Specification.

D. When shown on the Plans, flexible joint ductile iron pipe will be used instead of push-on joint pipe as shown on Design Standards. Flexible joint pipe will be laid such that the maximum joint deflection as specified by the pipe manufacturer for each joint is not exceeded.

E. The inlet, outlet, and any intermediate manholes will be constructed according to the requirements of Specification Section 02531.

F. The inlet and outlet manhole inverts will be carefully shaped to conform to the inlet and outlet pipes and cause the least possible resistance to flow. The inlet manhole will have an invert weir constructed to contain low flows to a single siphon pipe. The invert weir will be level across the top and constructed to the elevation shown on the Plans. The outlet manhole invert will be formed to reduce backflow into the inactive siphon pipes.

3.10 BACKFILLING

A. General

1. After sanitary sewer facilities have been bedded and installed according to these Specifications and upon permission of the Purchaser, the backfill may be placed. Backfilling operations shall continue following as closely behind pipe installation as practical. All backfill shall be placed in uniform horizontal layers. Pushing backfill material down a ramp into excavated areas will not be permitted. No trash will be allowed to accumulate in the space to be backfilled. Particular care shall be taken to avoid allowing wood to be included in the backfill, other than sheeting and shoring that has been approved by the Purchaser to be left in place.

2. The Subcontractor shall be responsible for the condition of the trenches and filled areas during the contract and warranty period. The Subcontractor shall maintain frequent inspection of the same. If at any time during the 12-month warranty period the trenches or filled areas settle and sunken places appear, the Subcontractor shall be required to refill these sunken places when they are discovered with suitable material and will replace all damaged curb, gutter, and sidewalk. All soft or dangerous trenches shall be marked, barricaded and caution lighted for the protection of the public.

3. Property with an existing dwelling located on it or lots within a developed subdivision or planned development are considered improved property.

B. Street Right-of-Way and Improved Property

1. Backfill Material: Backfill for manhole and pipe trench excavations through pavements in street or highway right-of-way or where the Purchaser orders, shall be made with pit run gravel or other acceptable material as approved by the Purchaser. The backfill shall be from the top of the pipe embedment material or manhole foundation to the subgrade elevation of the pavement. Pea gravel or similar granular material approximately uniform in size and without bonding properties will not be used.

2. Backfill for manhole and pipe trench excavations beyond pavements in street or

highway right-of-way or outside public right-of-way shall be made with select earth from the top level of the pipe embedment material or foundation to the subgrade elevation in paved area, or within 1 inch of the surface in areas to be sodded, or to the surface in all other areas.

3. Select material shall be free from debris, organic matter, perishable compressible material and will contain no stones or lumps larger than 6 inches. Rocks and lumps smaller than 6 inches will not exceed an amount that will interfere with the consolidating properties of the fill material. Care shall be taken that stones and lumps are kept separated and well distributed, and that all voids are completely filled with fine material. No rocks or lumps will come in direct contact with the pipe. The upper 3 feet of backfill in sodded or planted areas will be free of rocks or lumps larger than 1 inch in diameter.

4. Placement and Compaction:

   a. Sanitary Sewer Trenches: Backfill material shall be placed by hand in 6 inch loose layers and tamped to a point 2 feet above the outside top of the pipe. Backfill will be compacted with suitable mechanical tamping equipment with special care being taken not to damage the pipe or joints. Use of compaction equipment directly above semi-rigid and flexible pipe should be avoided until sufficient backfill has been placed to ensure that the equipment will not damage the pipe. A minimum of 36 inches of compacted backfill above the top of semi-rigid and flexible pipe shall be in place before wheel loading and a minimum of 48 inches of compacted backfill before use of pneumatic tampers. From these elevations to the subgrade elevation of the pavement, bottom of the sod, or to the original ground surface, suitable backfill shall be mechanically placed in 9 inch, maximum, loose layers. All backfill material shall be compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698).

   b. Manholes and Special Structures: When the masonry or concrete work has set sufficiently to withstand compaction, and the Purchaser authorizes, backfill material will be placed in 6 inch loose layers and compacted with heavy tampers or pneumatic tampers to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698). Suitable backfill shall be placed in this manner from the foundation of the structure to the subgrade elevation of the pavement, the bottom of the sod or to the original ground surface.

C. Open Areas and Unimproved Property

1. Backfill Material: Backfill of excavations on unimproved property shall be made with select material from the top level of pipe embedment material or foundation to the surface. Non-granular select material to be used for backfill will be free from debris, organic matter and perishable compressible material, and will contain no stones or lumps or rock fragments larger than 6 inches. Rocks or lumps smaller than 6 inches in diameter will not exceed an amount that will interfere with the consolidating properties of the fill material. No rocks or lumps shall come in direct contact with the pipe. Stones and lumps shall be kept separated and well distributed, and all voids shall be completely filled with fine material.

2. Placement of Backfill: Backfill procedures specified in Specification Section 02530 Paragraph 3.10.B shall apply from the trench bottom to a point 2 feet above the outside of the pipe. From this point to slightly above the surrounding surface elevation, suitable backfill may be placed by bulldozer or other mechanical means.

E. Removal of Excess Material

1. After the trench or excavation has been properly backfilled, all excess dirt shall be removed from the streets, roadways and improved private property so pavements or turfed areas may be replaced and properties cleaned.

2. In open areas and unimproved property, the excess material may be used to fill low spots on property next to the right-of-way/easement. Before spreading excess soil, the Subcontractor shall obtain written permission from the property owner for the spreading of excess soil, and a copy of the written permission shall be submitted to the Purchaser. Such spreading or filling shall not obstruct surface drainage and be to the satisfaction of the property owner. Excess material shall be disposed of by the Subcontractor.

3.11 BYPASS PUMPING

A. As required for acceptable completion of the work and/or to avoid damages due to sewer spills or overflows, the Subcontractor shall provide for sewer flow maintenance around the line segments and manholes designated for rehabilitation. The bypass shall typically be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent sanitary sewer system. The pump and bypass lines shall be of adequate capacity and size to handle the anticipated flow. Bypassing of sanitary sewage into the storm water system will not be allowed. For all bypass pumping, pump noise shall be kept to a minimum to the satisfaction of the Purchaser. The Subcontractor shall be required to contact all residential and commercial customers whose service lines connect to the sewer main being bypassed and inform them that they will be temporarily out of service. The Subcontractor shall also advise those customers against water usage until the mainline is back in service. After completing the necessary work on the main line, the Subcontractor shall advise those customers that the sewer main is back in service.

B. Bypass pumping is defined as providing pumps, standby pumps, piping, elevated structural support for aerial crossings, manpower to operate, routine maintenance and repair capability, pipe plugs, fuel, route and pump site clearing and any other work necessary to provide a complete bypass pumping operation. Any structures proposed by the Subcontractor for construction over or penetration into the interceptor piping for the purpose of performing the bypass operations must be approved by the Purchaser prior to implementation. The Subcontractor shall submit design drawings and details that are signed and sealed by a professional engineer licensed in the State of Tennessee. All bypass pump schemes must be submitted to and approved by the Purchaser in advance.

C. Public advisory services shall be required to notify all parties whose service laterals will be out of service and to advise against water usage until the mainline is back in service.

D. The Subcontractor shall be required to provide businesses with temporary service, as needed, and shall be responsible for all necessary bypass pumping flows.

3.12 TUNNELING, BORING, AND JACKING

A. General

1. Sewer pipe will be constructed by tunneling, boring, or jacking only at those locations shown on the plans or directed by the Engineer. Carrier pipe for these applications will be of the type specified in the Plans and Specifications. Grade and alignment will be maintained through all liner pipes. The Contractor will submit shop drawings detailing the

method, equipment and material to be used for tunneling, boring and jacking operations to the Engineer for review and approval. The approval by the Engineer of any drawings or plans will not in any way be deemed to release the Contractor from full responsibility for complete and accurate performance of the Work according to the Contract Drawings and Specifications.

2. When tunneling, boring, or jacking is required under railroads, highways, streets, or other facilities, construction will not interfere with the operation of the railroad, street, highway, or other facility and will not weaken or damage any embankment or structure. No water shall be introduced into any tunneling, boring or jacking excavation that lies within City, State or Rail Road right-of-way. A boring that uses a bentonite slurry may be allowed at the discretion of the Engineer and the owner of the right-of-way.

3. The Contractor will be responsible for protection of utilities and sewers against damage by his work. If any utility above or near the tunnel is endangered or has been damaged because of the construction operations, the utility owner will be notified immediately and will be given access to the area to carry out all necessary repairs to such utilities. If any sewers

are damaged, it will be the responsibility of the Contractor to make the necessary repairs. If any public or private property is endangered or has been damaged due to tunneling, boring, or jacking operations, it will be repaired at the Contractor's expense. All cost and expense to the Contractor of carrying out the above requirements will be considered included in his bid prices for the completed sewer installation.

4. Access pits will be of sufficient size to provide ample working space for the jacking or boring equipment, reaction blocks, bracing, liner plates, spoil removal, and 2 sections of pipe. Provisions will be made for the erection of guide rails in the bottom of the pit where applicable. If drainage is to be discharged from the jacking pit, a collection sump will be provided. Wherever end trenches are cut in the sides of the embankment or beyond it, such work will be sheeted securely and braced satisfactorily to prevent earth caving.

5. The Contractor will furnish and operate all necessary pumping equipment of ample capacity and arrange to keep tunnels and shafts free of water during construction and to dispose of water satisfactorily. During placement of concrete, drainage and pumping will be arranged so concrete is placed in dry conditions. No water will flow over the concrete until it has set and will not be damaged.

B. Tunneling

1. The Contractor will carry out the work of tunneling so there will be no cave-in or heaving of earth or other material into the tunnel excavation. If there should be any fall or movement of earth into the tunnel, the Contractor will proceed with the work with all necessary precautions to insure the safety of life and of sewers, utilities and public and private property above and near the tunnel.

2. The Contractor will furnish, place, and maintain all sheeting, bracing, lining or casing required to support the tunnel until the pipe and its bedding, jointing, encasement, and backfilling have been completed. All liners will remain in place.

3. Care will be used in trimming the surfaces of the excavated section and in placing the liners or sheeting and bracing so that the required minimum clearance between the outside of the pipe and the final position of the liners, sheeting and bracing in the tunnel will be attained without any deviation in sewer alignment. Sheeting or lining must be placed and held tightly against the trimmed earth surface of the excavated section so that there will be no voids between the earth and the lining or sheeting.

4. No part of the lining, bracing, or flanges of steel liner plates will project closer to the outside of the pipe or pipe bells than the clearance limits shown on the Plans, or a minimum of two inches, if not shown on the Plans.
5. If timber is used for lining and bracing instead of steel liner plates, invert struts will be placed at the required intervals but in such manner that the pipe and its bedding will be supported entirely by the original earth floor of the tunnel and not on timber lining or bracing. All timbers, when placed for the support of the roof and sides of the tunnel, will be properly fitted and wedged in place. Timber sets in tunnels will be abutting. All voids behind timbers will be filled with blocking or other suitable material.

6. Timbering will be designed and placed to allow the filling of voids. All excavated material not required for backfilling abandoned shafts will be removed from the site and disposed of by the Contractor at his expense.

7. Shafts will be constructed at the location shown on the Plans. Temporary construction shafts will be of adequate size and properly constructed and equipped to meet all safety requirements. All shafts will be barricaded, lighted, fenced, and properly guarded from the beginning of the excavation until the completion of the construction requiring the shaft.

8. Provision will be made at all shafts so that plumb lines suspended on the centerline of the sewer at each end of the shaft will hang freely from the surface.

9. A ladder meeting OSHA requirements will be provided in each shaft and will be kept in safe, good repair, clean and clear of debris.

10. Cavities between the surfaces of excavation and the tunnel liner plates or sheeting will be completely filled with a uniform sand cement grout consisting of 1 part portland cement and 7 parts sand and the minimum amount of water necessary for proper placement. Grout will be placed under pressure through grout holes in the steel liner plates or sheeting. The grout holes will be located and the grout placed in such sequence to insure the complete filling of all cavities and to transfer the load from the undisturbed material to the tunnel lining or sheeting uniformly.

11. After the tunnel section is excavated, lined, and braced, the pipe will be placed on and supported by steel rails or other approved supports. The supporting system will assure line and grade and will allow space below the pipe for concrete grout. Care will be used to avoid damage to the pipe and the liner plates.

12. The space between the pipe and the tunnel will be completely grouted with a mixture of sand and portland cement, mixed in the proportions of 1 part cement to 7 parts sand by volume and a minimum amount of water necessary for proper placement whether placed under pressure or by hand.

13. Temporary shafts will be completely abandoned. Unless otherwise specified in the Plans or Contract Documents all sheeting, bracing, and similar items may be removed unless the Contractor requests and receives authorization from the Engineer to leave it in place. No payment will be made for items left in place at the Contractor's option. If the Plans or the Engineer requires leaving the sheeting, bracing, and similar items in place, measurement will be made as provided in Specification Section 02530.5 and payment will be made as provided in Specification Section 02530.6.

C. Boring

1. When required by the Plans, sewers will be installed in bored holes. The holes will be

bored from the downstream end, unless site conditions dictate otherwise and the Engineer approves.

2. The boring machine to be used will be in good condition and capable of drilling the bore hole within the required limits of accuracy. A smooth liner of sufficient strength will be forced into the bored hole to give a tight fit against the earth sides of the bore hole and still provide a uniform clearance of at least two inches around the pipe flange to permit pressure grouting. The liner pipe will be carefully inspected to insure that the carrier pipe can be properly placed.

3. All carrier pipe shall be mechanical joint or restrained joint pipe. Manholes at the ends of a section of bored pipe will not be constructed until the bored section is completed.

4. The following procedures will be used for carrier pipe 18 inches and larger in diameter. The assembled pipe will be placed in the bored hole with approved, non-metallic, casing spacers attached. Casing spacers will be attached in accordance with the manufacturer's recommendations and with a casing spacer installed within 6 inches of each end of the bore. The assembled pipe will be placed in the bored hole only by such method that will keep the joints in compression. Any method that disjoints the pipe while being placed will not be permitted.

5. The ends of the bore shall be sealed with an approved, flexible end seal. The end seals shall be attached in accordance with the manufacturer's recommendations using stainless steel hardware.

6. When unforeseen obstructions or conditions require abandonment of a partially completed bore hole, and the starting of a new hole, the Contractor will grout the abandoned bore hole solid. The Contractor will receive no compensation for any expenses incurred by any unsuccessful attempt.

D. Jacking

1. The Contractor will furnish for the Engineer's review, a plan showing his proposed method of jacking, including the design for the jacking head, jacking support or back stop, arrangement and position of jacks, pipe guides, and similar items in the assembled position. The review of this plan by the Engineer will not relieve the Contractor from his responsibility to obtain the specified results.

2. Heavy duty jacks suitable for forcing the pipe through the embankment will be provided by the Contractor. In operating jacks even pressure will be applied to all jacks used. A suitable jacking head and bracing between jacks and jacking head will be provided so that pressure will be applied to the pipe uniformly around the circumference of the pipe. A suitable jacking frame or backstop capable of resisting the jacking forces will be provided. The pipe to be jacked will be set on guides, properly braced together to support the section of the pipe and to direct it in the proper line and grade. The whole jacking assembly will be placed to line up with the direction and grade of the pipe. The Contractor may use a cutting edge of steel plate around the head end of the pipe extending a short distance beyond the end of the pipe with the inside angles or lugs to keep the cutting edge from slipping back onto pipe.

3. The pipe will be jacked from the downstream end. Manholes at the ends of a section of jacked pipe will not be constructed until jacked section is completed.

4. Any pipe damaged in jacking operations will be removed and replaced by the Contractor at his own expense. Embankment material will be excavated just ahead of the pipe and material removed through the pipe, and the pipe forced through the embankment

with jacks, into the space thus provided.

5. The excavation for the underside of the pipe, for at least one-third of the circumference of
the pipe, will conform to the contour and grade of the pipe. A clearance of not more than 2 inches may be provided for the upper half of the pipe. This clearance is to be tapered off to zero at the point where the excavation conforms to the contour of the pipe.

6. The distance that the excavation will extend beyond the end of the pipe depends on the character of the material, but it will not exceed 2 feet in any case. This distance will be decreased if the character of the material being excavated makes it desirable to keep the advance excavation closer to the end of the pipe.

7. A cushion material will be placed in the joints between each pipe section adequate to distribute the jacking forces around the entire periphery of the pipe uniformly.

8. When jacking of pipe is begun, the operation will be carried on without interruption, as much as practicable, to prevent the pipe from becoming firmly set in the embankment.

9. The pits or trenches excavated to allow jacking operations will be backfilled immediately after the jacking of the pipe has been completed according to Specification Section 02530 Paragraph 3.11.

E. Sewer Pipe in Jacked Liner

1. When required by the Plans or Contract Documents, a sewer pipe will be installed by jacking a pipe as a liner and inserting a carrier pipe of required size, type, and class. When using jacking for liners, the steel liner will be welded steel, 35,000 psi yield strength, and of the diameter and wall thickness required on the Plans and Specifications. The Contractor will provide, at his own expense, thicker walled lines if necessary to withstand the forces of jacking. In any case, the Contractor will retain full responsibility for the adequacy of this jacking operation, equipment and material.

3.13 FINAL GRADING

A. Final grading around sanitary sewer facilities shall conform to the elevation of adjacent undisturbed ground or as shown on the Drawings. Sufficient grading shall be done to provide adequate drainage.

3.14 CLEANING

A. All necessary precautions shall be taken to prevent the entrance of mud, sand, or other obstructing material into the pipelines. As the work progresses, the interior of the sewer shall be cleaned of all dirt, jointing material and extraneous material. On small pipe where cleaning after laying may be difficult, a squeegee shall be kept in the pipeline and pulled forward past each joint immediately after its completion. Before final inspection the Subcontractor shall remove all debris and foreign material.

3.15 TRAFFIC CONTROL

A. All traffic control shall be installed and maintained in accordance Section 01551 – Traffic Control for Work Zones. At a minimum, the Subcontractor must have two trucks with flashing yellow lights on the work site. Traffic cones must also be placed downstream of the construction site to divert cars into the adjacent lane(s) per MUTCD requirements. On roads with a heavy traffic volume, a flagman may also be needed to assist with traffic

control. At the end of each working period, the Subcontractor shall plate all open excavations to maintain traffic flow.

3.16 FALL PROTECTION

A. Subcontractor shall install and maintain all fall protection measures in accordance with the SARP10 Loss Control Manual. The Subcontractor shall construct a controlled access zone around the manhole being adjusted. At a minimum, the fall protection zone shall include traffic cones encircled with pennant tape. The controlled access zone must have one point of access with an entrance log.

3.17 PROTECTION OF DOWNSTREAM FACILITIES

A. The Subcontractor must take all steps necessary to assure that no material is allowed to fall into the line during his installation process. The Subcontractor shall bear all cost of repairs resulting from any damages to downstream facilities resulting from failure to abide by this stipulation.

3.18 WASTEWATER SPILLS

A. Should the Subcontractor spill any wastewater, such that the sewage either immediately or ultimately enters the waters of the State of Tennessee, then the Subcontractor shall be completely responsible for any fines or penalties imposed on the Purchaser or the Subcontractor by the USEPA or the State of Tennessee.

PART 4- FINAL TESTING AND ACCEPTANCE

4.01 VISUAL INSPECTION

A. All work will be subject to visual inspection for faults or defects and any such deviation or omission will be corrected at once.

B. A PACP CCTV inspection in accordance with Section 00003 shall be submitted after pipe replacement is competed.

4.02 LEAKAGE TESTS

A. On sewers with no house connections, leakage tests shall be performed on the full length of all sewer lines and manholes in the presence of the Purchaser before acceptance. On all other sewers, an infiltration test shall be performed. The cost of all testing will be included in the unit price for the item being tested.

B. Air Leakage Test for 8-24 inch Diameter Pipe

1. Upon completion of construction, or earlier if the Purchaser deems advisable, the Subcontractor shall provide the necessary equipment and labor to perform low pressure air tests according to ASTM F1417. This test shall be performed in the presence of the Purchaser and shall be for all types of gravity sewer pipe. This test shall also include service lines from manholes.

2. The pressure test gauge will meet the following minimum specifications:

a. Size (diameter) 4 ½ inches
b. Pressure Range 0-15 PSI
c. Figure Intervals 1 PSI Increments

d.	Minor Subdivisions	0.05 PSI
e.	Pressure Tube	Bourdon Tube or diaphragm
f.	Accuracy	Plus or minus 0.25% of Maximum scale reading
g.	Dial	White coated aluminum with black lettering, 270° arc and mirror edges
h.	Pipe Connection	Low male ½ inch NPT

3. Calibration data shall be supplied with all pressure test gauges. Certification of pressure test gauges shall be required from the gauge manufacturer. This certification and calibration data shall be available to the Purchaser whenever air tests are done.

4. Air leakage tests shall be performed on each reach of sewer pipe between manholes after completion of the installation of pipe and appurtenances and the backfill of sewer trenches. The test time shall be determined from the following table. If air tests fail to meet the following requirements, the Subcontractor shall repeat tests as necessary after all leaks and defects have been repaired. Before acceptance, the same sewer reach shall pass the low pressure air test.

Time Required for a 1.0 psig Pressure Drop for Size and Length of Pipe Indicated[1]

Pipe Diameter (in.)	Minimum Time (min:sec)	Test Time for Length of Sewer Tested (min)
8	7:34	1.52 X L(ft)/60
10	9:26	2.374 X L(ft)/60
12	11:20	3.418 X L(ft)/60
15	14:10	5.342 X L(ft)/60
18	17:00	7.692 X L(ft)/60
21	19:50	10.47 X L(ft)/60
24	22:40	13.674 X L(ft)/60

1. Establish the test time for the sewer length from the formula or the minimum time, whichever is greater.

C. Infiltration Test

1. Infiltration tests may be required for the complete line or any portion of it. Failure of any part of the line to pass an infiltration test shall be sufficient reason to require additional work by the Subcontractor to reduce the infiltration in such portions of the line tested. The passing of an infiltration test shall in no way relieve the Subcontractor of any responsibility to repair visible leaks found during the visual inspection.

2. Maximum allowable infiltration shall be 0 gallons per mile per inch of diameter of sewer per 24-hour day at a time. The joints shall be tight, and visible leakage in the joints of leakage greater than that specified above shall be repaired at the Subcontractor's expense by any means necessary.

4.03 DEFLECTION TEST - SEMIRIGID AND FLEXIBLE PIPE

A. All polyvinyl chloride (PVC) pipe and glass fiber reinforced polymer mortar pipe shall be tested for deflection. All testing shall take place after backfill has been in place at least 30 days. All lines shall be thoroughly cleaned before testing to assure accuracy.

B. Tests shall be run using a rigid ball or nine arm mandrel having a diameter of 95% of the inside diameter of the pipe for PVC and 96% of the inside diameter of the pipe for glass fiber reinforced polymer mortar pipe. The mandrel will be pulled freely by hand through the pipe from manhole to manhole. No pipe deflection will exceed 5% for PVC and 4% for glass fiber reinforced polymer mortar pipe. Any section failing the test shall be repaired by re-bedding or pipe replacement and retested to the satisfaction of the Purchaser.

C. The cost of this service shall be included in the unit price bid for the pipe.

4.04 FINAL ACCEPTANCE

A. When all work required by the Contract has been completed, the Subcontractor shall submit to the Purchaser written certification from a registered land surveyor that the centerline of each structure is within 2.0 feet of the centerline of the sewer easement or the location designated on the Drawings. After receiving the surveyor's certification from the Subcontractor, the Purchaser will make a final inspection of the Work, including any tests for operation. After completion of this inspection, the Purchaser will, if all things are satisfactory to him, issue to the Subcontractor a Certificate of Completion certifying that the Work required by the Contract has been completed according to the Contract Drawings and Specifications. However, the Certificate will not operate to release the Subcontractor or his sureties from any guarantees under the Contract or the Performance Bond. Upon receipt of the Certificate of Completion the Subcontractor will clean the premises and see that they are in an orderly condition.

PART 5- MEASUREMENT

5.01 LOCATE AND EXPOSE MAINLINE TERMINUS

A. Locate and expose mainline terminus shall be measured per each.

5.02 UNDERCUT BACKFILL

A. Undercut backfill will be measured by the ton of limestone in place.

5.03 SEWER PIPE

A. Sewer pipe length will be measured per linear foot along the centerline of the pipe from center of manhole to center of manhole. When there are special structures, sewer pipe will be measured from inside face to inside face for the various sizes, types, classes or wall thicknesses.

B. Sewer pipe length measurement will include the length of wyes as measured along the primary axis for all sizes of sewer pipe.

5.04 SERVICE CONNECTION REMOVAL AND REPLACEMENT

A. Service connection removal and replacement for construction of sewer facilities will be measured per each. Service Connections damaged by the Subcontractor that do not require removal and replacement for construction of sewer facilities will not be measured for payment.

5.05 PAVEMENT BACKFILL

A. Pit run gravel or other acceptable material used for backfill under pavements or other areas directed by the Purchaser will be measured by the cubic yard in the following manner. Cubic yards of Pavement Backfill equals the linear feet of sewer pipe installed directly below pavement as measured along the centerline of the pipe multiplied by the trench payline width in feet multiplied by the depth of pavement backfill material in feet divided by 27. The trench payline width is defined as the outside diameter of the sewer pipe plus 2 feet. The depth of pavement backfill is defined as the distance from 6 inches above the top of the sewer pipe to the subgrade elevation of the pavement.

5.06 BYPASS PUMPING

A. There is an allowance for this item and as such no specific measurement will be made. The bypass cost for a specific relay will be submitted by the subcontractor to the Program Manager prior to any work under this item. Any work to be paid under this item must be approved by the Program Manager prior to work beginning.

5.07 TRAFFIC CONTROL

A. Traffic control will be measured as specified in Section 01551 – Traffic Control for Construction Work Zones.

5.08 INVERTED SIPHONS

A. Inverted siphons constructed according to Plans and Specifications will be measured per lump sum for each siphon complete in place.

5.09 HYDROEXCAVATION/HAND DIGGING

A. Hydroexcavation and/or hand digging of the trench perimeter will be measured per linear foot of sewer pipe replaced.

5.10 EXCAVATION

A. All work for excavation, blasting, drainage of trenches and dewatering, backfilling of excavation, compaction, grading, protection of existing utilities, disposal of excess material, and all other similar items included in this section of the Specifications but not covered by a Pay Item herein will be considered obligations of the Subcontractor under other Pay Items of the Contract.

5.09 PIPE WYES

A. Pipe wyes on sewer lines will not be measured for payment, but are incidental to the cost of furnishing and installing sewer pipe.

5.10 STEEL CASING

A. Measurement shall be along the centerline of the installed steel casing pipe. Measurement shall not be made of incidental work, including sheeting, shoring, grout, excavation, backfill, dewatering, or other work related to installing the steel casing pipe complete and in place.

PART 6 - PAYMENT

6.01 LOCATE AND EXPOSE MAINLINE TERMINUS

A. Locate and expose mainline terminus will be paid for at the contract unit price per each. This item will include but not be limited to all means necessary for locating and excavating the terminus of the sewer when no manhole exists. This item will not include any pay items related to the installation of a new manhole.

6.02 UNDERCUT BACKFILL

A. Accepted quantities of undercut backfill will be paid for at the contract unit price per ton of limestone furnished and placed, which will be full compensation for undercut excavation, special protection, protection of existing utilities, and backfilling to bottom of facility subgrade elevations, complete in place.

6.03 SEWER PIPE

B. The accepted quantities of all sewer pipe will be paid for at the contract unit price per linear foot furnished and laid for the various sizes, types, classes, or wall thicknesses of pipe, which will be full compensation for material and material testing, excavation, special protection, protection of existing utilities, maintenance of sewage flow, proper pipe embedment, laying, jointing, cleaning and inspection, conducting acceptance tests, installation of pipe wyes, connection to manholes, adapters and couplings, stoppers, and removal and/or abandonment of existing pipe within the limits of excavation and backfilling outside pavement areas.

6.04 SERVICE CONNECTION REMOVAL AND REPLACEMENT

A. Accepted quantities of building connections removed and replaced will be paid for at the contract unit price per each for various types of building connections, which will be full compensation of excavation, removal of old service line and appurtenances, furnishing and construction of new service lines, connection fitting to main sewer, PVC 4-inch stack pipe, double sweep cleanout, PVC cap with screw plug, 6-inch by 4-inch PVC reducer, and connection to the existing private lateral and appurtenances to remain, backfilling, testing and inspection, complete in place.

6.05 PAVEMENT BACKFILL

A. Accepted quantities of pit run gravel or other acceptable material used for backfill under pavements or other areas designated by the Purchaser will be paid for at the contract unit price per cubic yard furnished and placed, which will be full compensation for furnishing, placing and compacting the selected material.

6.06 BYPASS PUMPING

A. There is an allowance for this item. This item includes all materials and labor necessary to properly comply with the bypass pumping requirements listed in the specification. The bypass cost for a specific relay will be submitted by the subcontractor to the Program Manager prior to any work under this item. Any work to be paid under this item must be approved by the Program Manager prior to work beginning. This item will not be paid until submittal and approval of the post construction inspection data associated with the point repair.

6.07 TRAFFIC CONTROL

A. Traffic Control will be paid as specified in Section 01551 – Traffic Control for Construction Work Zones. Traffic control does not apply to segments being replaced in alleys or other locations where traffic is not impacted.

6.08 HYDROEXCAVATION/HAND DIGGING

A. Hydroexcavation and/or hand digging of the trench perimeter will be paid per linear foot of pipe installed where one of these methods is used. Payment shall include all material and labor required to complete the item as specified.

6.10 STEEL CASING

A. The accepted quantities of all still casing pipe will paid for at the contract unit price per linear foot furnished and laid for the various sizes, types, classes, or wall thicknesses of pipe, which will be full compensation for installation, labor, pipe, materials, equipment, tools and incidentals necessary to complete the work.

PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02530-6.01	LOCATE AND EXPOSE MAINLINE TERMINUS	Each
02530-6.02	UNDERCUT BACKFILL	Ton
02530-6.03	**SEWER PIPE**	Linear Foot
02530-6.03.06.10	10” DUCTILE IRON PIPE, CLASS 50	Linear Foot
02530-6.03.15.08.01	8” POLYVINYL CHLORIDE (PVC) 0’ - 6’ DEEP	Linear Foot
02530-6.03.15.15.01	15” POLYVINYL CHLORIDE (PVC) 0’ - 6’ DEEP	Linear Foot
02530-6.03.15.15.02	15” POLYVINYL CHLORIDE (PVC) 6.1’ – 12’ DEEP	Linear Foot
02530-6.03.15.24.01	24” POLYVINYL CHLORIDE (PVC) 0’ - 6’ DEEP	Linear Foot
02530-6.03.15.24.02	24” POLYVINYL CHLORIDE (PVC) 6.1’ - 12’ DEEP	Linear Foot
02530-6.03.15.30.01	30” POLYVINYL CHLORIDE (PVC) 6.1’ - 12’ DEEP	Linear Foot
02530-6.04	SERVICE CONNECTION REMOVAL AND REPLACEMENT	Each
02530-6.05	PAVEMENT BACKFILL	Cubic Yard
02530-6.06	BYPASS PUMPING	Lump Sum
02530-6.08	HYDROEXCAVATION/HAND DIGGING	Linear Foot
02530-6.10	STEEL CASING	Linear Foot

END OF SECTION 02530

PART 1 - SCOPE

1.01 Pavement markings are painted or plastic markings applied to the street surface for regulating, warning, or guiding traffic on the street. The work covered by this section shall consist of furnishing and supplying pavement markings in accordance with these Specifications and the latest revision of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) published by the Tennessee Department of Transportation and in conformity with the lines, dimensions, patterns, locations, and details shown on the Plans or established by the Owner.

1.02 This Section describes the general and specific requirements for conventional and rapid dry pavement marking paint, reflective hot plastics, reflective cold preformed plastics, pliant polymer film, sheeting or tape, powder pavement marking materials, glass beads for reflective pavement marking paint and plastics, and raised reflective pavement markers used by the City in its pavement marking program.

PART 2 - MATERIALS AND EQUIPMENT

The methods of sampling and testing all materials and products covered by this specification shall be in accordance with the latest standards of the American Society for Testing Materials, the American Association of State Highway and Transportation Officials, the Federal Government, or of other recognized standardizing agencies as indicated for each material.

2.01 MATERIALS

A. Conventional Reflective Pavement Marking Paint (Type “A” Paint).
This describes the general and specific requirements for reflective pavement marking paints to be used by the City in its pavement marking program. This covers ready mixed paint products of spraying consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavements. The paint type relative to drying time hereinafter shall be referred to as conventional paint – over 3 minutes drying time (requiring line protection devices).

1. General Properties.

a. Condition and Stability.
The paint shall be homogeneous, shall be well ground to a uniform and smooth consistency and shall not skin or settle badly, nor cake, liver, thicken, curdle or gel in the container. The paint shall be capable of being broken up and mixed without difficulty by use of a paddle and shall show the desired characteristics at any time within a period of 6 months from the date of delivery. The paint shall be tested in accordance with ASTM D 869 and D1309 and a paint rated below six (6) shall be considered unsatisfactory.

b. Foreign Matter.
The paint shall be free from skins, dirt and other foreign matter and shall not contain more than 1 percent water. The paint shall be tested in accordance with methods 4081, 4091 and 4092 of Federal Test Method No. 141.

c. Suitability to Application.
The paint shall be suited to application by means of spray type pavement marking equipment used by the City and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

d. No Tracking Time.
The conventional paint, when applied with glass spheres to dry concrete or bituminous pavement surface under normal field conditions at the required application rates with pavement temperature between 35^0F and 45^0F and under all humidity conditions suitable for applying paint, shall dry to a no tracking condition in 45 minutes. The no tracking time shall

be determined by passing over the line in a simulated passing maneuver with a passenger car after the expiration of above time. A line showing no visual paint deposition to the pavement surface when viewed from a distance of 50 feet shall be considered as showing no tracking and conforming to the requirements for field drying conditions. The paint may also be tested in accordance with ASTM D 711 and when so tested, shall dry to no pickup in 30 minutes.

e. Viscosity.
The conventional paint, as received, shall have a consistency determined on the Stormer Viscosimeter and expressed as Krebs Units at 77^0 of 70-80 K.U. Any paint which changes consistency within six months after receipt so that the consistency falls outside the viscosity limits stated above shall be considered to have failed this requirement.

f. Color.
The paint shall visually match the Federal Highway Administration color tolerance chart for standard highway yellow or white. The color determination shall be made after the paint has dried for 24 hours on premix as received and on combination and drop-on types after the beads have been dropped in. The paint shall not contain any organic coloring matter and shall not discolor in sunlight.

g. Bleeding.
When tested and evaluated on both tar and asphalt substrates in accordance with the Method of Laboratory Test for Degree of Resistance of Traffic Paint to Bleeding, ASTM D 969, and The Method of Evaluating Degree of Resistance of Traffic Paint to Bleeding, ASTM D 868, the numerical rating of degree of bleeding shall not be less than six (6). Paints will be tested for bleeding with the prescribed quantity of glass spheres in or on the paint.

h. Hiding Power.
The pigmented binder, when tested in accordance with Method 4121 of Federal Test Method 141, “Dry Opacity,” and when applied at the rate of 10 mils wet film thickness over a Morest Black and White Hiding Power Chart, Form 03-B, shall show complete hiding or give a contrast ration of not less than 0.98 between the reflectance of the black and of the white chart surfaces as determined by a Hunter Multipurpose Reflector.

2. Packaging.
Paint purchased under this Specification for regular use by the City shall be shipped in clean, open headed pails of 5 gallons capacity, sealed, vapor proof, and meeting current Interstate Commerce Commission requirements. Each container shall be plainly marked, both on the head and side, with a durable, weather resistant ink or paint, showing the name and address of the manufacturer or vendor, description of material, purchase order number, batch number and volume and weight of contents.

3. Special Handling or Use Instructions.
Any special handling, storage or use instructions made necessary by the use of unusually flammable solvents shall be provided by the manufacturer.

B. Rapid Dry Reflective Pavement Marking Paint (Type “B” Paint).
This describes the general and specific requirements for reflective pavement marking paints to be used by the City in its pavement marking program. This covers ready mixed paint products of spraying consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavements. The paint type relative to drying time hereinafter shall be referred to as rapid dry paint—1 to 3 minutes drying time. The rapid dry paint is heated during application to achieve uniform sprayable viscosity.

1. General Properties.

a. Condition and Stability.
The paint shall be homogeneous, shall be well ground to a uniform and smooth consistency and shall not skin or settle badly, nor cake, liver, thicken, curdle or gel in the container. The paint shall be capable of being broken up and mixed without difficulty by use of a paddle and shall show the desired characteristics at any time within a period of six months from the date of delivery. The paint shall be tested in accordance with ASTM D 869 and D 1309 and a paint rated below six (6) shall be considered unsatisfactory.

b. Foreign Matter.
The paint shall be free from skins, dirt and other foreign matter and shall not contain more than 1 percent water. The paint shall be tested in accordance with methods 4081, 4091 and 4092 of Federal Test Method No. 141.

c. Suitability to Application.
The paint shall be suited to application by means of spray type pavement marking equipment used by the City of Memphis and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

d. No Tracking Time.
The rapid dry paint, when applied with glass spheres to dry concrete or bituminous pavement surface under normal field conditions at the required application rates with pavement temperature between 35^0F and 45^0F and under all humidity conditions suitable for applying paint shall dry to a no tracking condition in 60 seconds. The no tracking time shall be determined by passing over the line in a simulated passing maneuver with a passenger car after the expiration of above time. A line showing no visual paint deposition to the pavement surface when viewed from a distance of 50 feet shall be considered as showing no tracking and conforming to the requirements for field drying conditions. The paint may also be tested in accordance with ASTM D 711 and when so tested, shall dry to no pickup in 8 minutes.

e. Viscosity.
The rapid dry paint, as received, shall have a consistency determined on the Stormer Viscosimeter and expressed as Krebs Units at 77^0 of 90-110 K.U. Any paint which changes consistency within 6 months after receipt so that the consistency falls outside the viscosity limits stated above shall be considered to have failed this requirement.

f. Color.
The paint shall visually match the Federal Highway Administration color tolerance chart for standard highway yellow or white. The color determination shall be made after the paint has dried for 24 hours on premix as received and on combination and drop-on types after the beads have been dropped in. The paint shall not contain any organic coloring matter and shall not discolor in sunlight.

g. Bleeding.
When tested and evaluated on both tar and asphalt substrates in accordance with the Method of Laboratory Test for degree of Resistance of Traffic Paint to Bleeding, ASTM D 969, and The Method of Evaluating Degree of Resistance of Traffic Paint to Bleeding, ASTM D 868, the numerical rating of degree of bleeding shall not be less than six (6). Paints will be tested for bleeding with the prescribed quantity of glass spheres in or on the paint.

h. Hiding Power.
The pigmented binder, when tested in accordance with Method 4121 o f Federal Test Method 141, “Dry Opacity”, and when applied at the rate of 10 mils wet film thickness over a Morest Black and White Hiding Power Chart, Form 03-B, shall show complete hiding or give a

contrast ratio of not less than 0.98 between the reflectance of the black and of the white chart surfaces as determined by a Hunter Multipurpose Reflector.

2. Packaging.

Paint purchased under this specification for regular use by the City shall be shipped in clean, open headed drums of 55 gallons capacity, sealed, vaporproof, and meeting current Interstate Commerce Commission requirements. Each container shall be plainly marked, both on the head and side, with a durable, weather resistant ink, or paint, showing the name and address of the manufacturer or vendor, description of material, purchase order number, batch number and volume and weight of contents.

3. Special Handling or Use Instructions.

Any special handling, storage or use instructions made necessary by the use of unusually flammable solvents shall be provided by the manufacturer.

C. Hot Extruded and Hot Spray Thermoplastics.

1. Type of Material.

This section covers thermoplastic materials suitable for use as reflecting pavement markings on Portland cement concrete or bituminous pavement. The materials shall be manufactured for application by extrusion or spraying onto the pavement in molten form with glass spheres mixed in and also dropped into the material immediately after it is applied.

2. General Characteristics.

The compound shall resist deterioration by contract with sodium chloride, calcium chloride or other chemicals used to prevent roadway ice, or because of the oil content of pavement materials or from oil droppings or other effects of traffic. In the plastic state, materials shall be free of fumes which are toxic or otherwise injurious to persons or property. The material shall withstand deterioration if held at the plastic temperature for a period of four hours, or by reason of three reheatings to the plastic temperature. The temperature versus viscosity characteristics of the plastic material shall remain constant through up to three reheatings and shall be the same from batch to batch. The color shall be stable for at least three reheatings and between batches. To insure the best possible adhesion, the compound, as specified, shall be installed in a melted state at the temperature recommended by the manufacturer, and the material shall retain its color if kept at this temperature for up to four hours.

a. Foreign Matter.

The binder shall consist of a mixture of resins, at least one of which is solid at room temperature. The total binder content of the thermoplastic compound shall be a minimum of 15 percent and a maximum of 35 percent by weight. The pigmented binder shall be well dispersed and free from all skins, dirt, foreign objects or such ingredients as will cause bleeding, staining, or discoloration. The filler shall be a white calcium carbonate silica or an equivalent filler with a compression strength of 5,000 pounds per square inch (34.5 MPa).

b. Suitability for Application.

The thermoplastic material shall be a product especially compounded for traffic markings. The markings shall remain intact under normal traffic conditions at temperatures below 140^0F (60^0C). The markings shall have a uniform cross-section. Pigment shall be evenly dispersed throughout the material. The density and character of the material shall be uniform throughout its thickness. The stripe shall maintain its original dimensions and placement. The exposed surface shall be free from tack and shall not be slippery when wet. The material shall not lift from the pavement in freezing weather. Cold ductility of the material shall be such as to permit normal movement with the road surface without chipping or cracking.

c. Drying Time.

The drying time shall follow a characteristic straight line function, the lower limits of which are

2 minutes maximum at 50^0F (10^0C), the upper limits of which are 15 minutes at 90^0F (32.2^0C), both temperatures measured as surface temperatures. After application and proper drying time, the material shall show no appreciable deformation or discoloration under local traffic conditions or in air and/or road temperatures ranging from -20^0F to 120^0F (-30^0C to 50^0C).

d. Reflectorization.
During manufacture, reflectorizing glass spheres shall be mixed into the material as follows by weight of the material; Extruded Thermoplastic -- 20 percent minimum to 50 percent maximum. Hot Spray Thermoplastic -- 20 percent minimum to 30 percent maximum. Glass spheres shall also be automatically applied to the surface of the material at a uniform rate of approximately 6 pounds (2.72 kg) of glass spheres of every 100 square feet (9.29 m^2) of line. These glass spheres shall be dropped or sprayed onto the thermoplastic material while it is in a molten state immediately after it has been applied to the pavement. Required properties of glass spheres used in hot thermoplastic installations are described in Specification Section 02760 Paragraph 2.01 J.

3. Physical Requirements.

a. Color.
The color shall conform to the following when tested by Federal Test Method Standard 141 Method 4252;
White: Federal Color Chip No. 37875 (Fed. Std. No. 595).
Yellow: Federal Color Chip No. 33535 (Fed. Std. No. 595).

b. Water Absorption.
Materials shall have a maximum of 0.5 percent by weight of retained water when tested by ASTM D 570. “Water-Absorption of Plastics”, procedure (A).

c. Softening Point.
Materials shall have a softening point of 190^0F (87.8^0C) minimum, as determined by ASTM E 28, “Method of Test for Softening Point by Ring and Ball Apparatus”.

d. Specific Gravity.
Specific gravity of the thermoplastic compound, at 77^0f (23.2^0C), shall be from 1.6 to 2.3.

e. Impact Resistance.
Impact resistance shall be a minimum of 10 inch pounds (1.13J) at 77^0F (23.2^0C) after the material has been heated for four hours, at application temperature and cast into bars of 1 inch (2.54cm) cross-sectional area, 3 inches (7.62 cm) long and placed with 1 inch (2.54 cm) extending above the vice in a cantilever beam (Izod type) tester using the 25 inch-pound (2,825 J) scale. This instrument is described in ASTM D 256.

f. Abrasion Resistance.
The material shall show a maximum loss of 0.5 grams when subjected to 200 revolutions on a Taber Abraser at 77^0F (23.2^0C) using H-22 calibrate wheels weighted to 500 grams. The panel for this test will be prepared by forming a representative lot of material at a thickness of 125 mils (3.175 mm) on a 4 inch square (25.8 cm^2) monel panel 0.050 inch (1.27 mm) thick, on which a suitable primer has been applied. The wearing surface shall be kept wet with distilled water during the test.

4. Packaging.

a. The material shall be delivered in containers of sufficient strength to permit normal handling during shipment and transportation on the job without loss of material. Each container when filled shall weigh a minimum of 21 pounds (9.59 kg) and a maximum of 52

pounds (23.6 kg).

b. Each unit container shall be clearly and adequately marked to indicate the color of the material, the process batch number or other similar manufacturer's identification, the manufacturer's name, address of the plant and the date of manufacture.

D. Cold Thermoplastics.

1. Type of Material.
This section covers reflectorized cold thermoplastic materials preformed into rolls or ribbons of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or bituminous pavement.

2. General Characteristics.

a. Reflectorized cold plastic pavement marking material shall consist of homogeneous, extruded, prefabricated thermoplastic ribbon of specified thickness and width of either white or yellow color and shall contain reflective glass spheres uniformly distributed throughout the entire cross-section that shall be capable of being affixed to nonbleeding bituminous or Portland cement concrete pavements. The reflectorized material shall be of the plastic, cold flow type.

b. The reflectorized cold plastic pavement marking material shall consist of the following components with maximum and minimum composition by weight tolerances as shown:

	Maximum	Minimum
Plastics and Plasticizers	46%	40%
Pigments	42%	38%
Glass Spheres	18%	14%

c. Pigments shall include titanium dioxide conforming to the requirements of ASTM D 476 for white plastic material and CP medium chrome yellow conforming to the requirements of ASTM D 211 for yellow materials. Reflective glass spheres shall contain the physical properties described in Specification Section 02760 Paragraph 2.01 H.

d. When extruded, the reflectorized cold thermoplastic material without precoated adhesive shall be 0.09 inch thick, with a tolerance of plus or minus 5 percent. The edges shall be clear cut and true. The cold plastic material may be supplied complete with a precoated, factory applied adhesive backed with a protective release paper so as to make possible immediate pavement application without the use of heat, solvent, or other types of adhesive operations or it may be furnished with separate adhesives as recommended by the manufacturer. Whether the adhesive is precoated or supplied separately, the adhesive shall be such as to allow the cold thermoplastic material to be repositioned on the pavement surface to which it is applied before permanently fixing it in its final position with a downward pressure.

3. Physical Requirements.

a. Bend Test No. 1 (With Precoated Adhesive).
The plastic shall be of such a structure that at a temperature of 80^0F, a piece of 3 inch x 6 inch material (with paper backing) placed upon a 1 inch diameter mandrel, may be bent over the mandrel until the end faces are parallel and 1 inch apart. By visual inspection, there shall be no fracture lines apparent in the uppermost surface.

b. Bend Test No. 2. (Without Paper Backing).
A piece of plastic 6 inch x 12 inch in size (paper backing removed) when balanced upon a supported ½ inch diameter mandrel, reflective side up, and left in this position at a

temperature of 80^0F, shall have flexed out of its own weight at the end of eight hours into an inverted "V" position with the free ends at an angle of not more than 30^0 from the vertical. The uppermost surface of the plastic shall show no fracture or breaks. Upon removing the plastic from the mandrel, the material should be firmly but not abruptly returned to a semi-flat position with the reflective side down. The plastic, at a temperature of 80^0F on a smooth, flat, glass surface, shall have returned to its original flat condition in not more than 8 hours.

c. Tensile Strength.
Employing ASTM D 638, the plastic shall have a tensile strength of 300 psi plus or minus 100 psi. The elongation shall be no greater than 50 percent. The tensile strength calculations should be based on the minimum measured thickness of the test specimen. The rate of pull of the test shall be 0.25 inch per minute. The test shall be conducted at a temperature of 70^0 to 80^0 F using a strip of material 6 inches long and 1 inch wide.

d. Plastic Pull Test.
A 6 inch long by 1 inch wide section of the thermoplastic material shall support a dead load weight of 6 pounds for not less than thirty minutes. This test shall be conducted at a temperature of 70^0 to 80^0 F.

e. Glass Sphere Retention.
A 2 inch specimen of thermoplastic material shall be cut at right angle to the beveled edge and bent parallel to the beveled edge on a ½ inch diameter mandrel. While the specimen is bent, a strip of ½ inch wide masking tape shall be applied firmly along the length of the area of maximum bend and then removed. Retention of any glass spheres on the masking tape when the tape is removed shall be cause for rejection of the material

f. Gloss.
The plastic material shall have a maximum 60^0 gloss of 10 units as measured in accordance with ASTM D 523.

g. Abrasion Resistance.
The plastic material shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to Federal Test Method Standard No. 141 (Method 6192), using H-18 calibrate wheels with 1,000 gram load on each wheel.

4. Suitability for Application.

a. The cold thermoplastic material shall be capable of application to nondefective pavement surfaces that are free from dirt or other foreign matter and at a temperature of 60^0F or more.

b. Adhesive, activators, or special coatings for various types of pavement surfaces shall be provided with the thermoplastic material. Detailed information must be supplied with the thermoplastic material outlining required application procedures for such adhesives, activators, or special coating.

c. Cold plastics shall be capable of being applied to new asphaltic pavement immediately prior to the final rolling of the new surface and of being rolled into place with conventional pavement and highway rollers. The plastic material and adhesives used in such applications shall be of the type that water used on the road roller to prevent asphalt pickup shall not be harmful to the successful application of the plastic.

5. Packaging.
The cold thermoplastic strips shall be supplied in rolls or strips of specified lengths (usually 150 feet), of the width specified, except for standard symbols and words. Rolls or strips shall be packaged in cartons suitable to allow for easy dispensing.

E. Pliant Polymer Films.

1. Type of Material.

This section covers reflectorized pliant polymer film materials processed into rolls or ribbons of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement.

2. General Characteristics.

a. Reflectorized pliant polymer film shall consist of a laminated retroreflective coating of glass beads bonded to a conformable resilient pliant polymer film white or yellow in color which is protected on the reverse side by a protective liner. This liner is removed before application. The marking film shall have reflective elements uniformly dispersed throughout and when properly applied using a specially designed contact cement shall conform and adhere to asphaltic concrete and portland cement concrete surfaces.

b. Color shall be white and yellow, consistent with normal highway use.

c. The normal thickness of the marking films shall be available as follows:

White	Yellow
0.06" (1.5mm)	0.06" (1.5mm)

3. Physical Requirements.

a. The marking film shall have the following average minimum brightness values at 0.2^0 and 0.5^0 observation angles and 86^0 entrance angle, measured in accordance with the photometric testing procedure in Federal Specification FP-74, Section 718.01 (a), except that the brightness values shall be expressed as candlepower per foot candle per 5 sq. ft. panel (2-1/2 feet by 2 feet (0.76 m x 0.61 m)). The five square feet is derived from a standard stripe, defined as 4 inches by 15 feet = 5 sq. ft. (10.1 cm by 4.57 m = 0.46 sq. meters).

b. Brightness Values (candle power per foot candle per 5 sq. ft.)

	White		Yellow	
Observation Angle	0.2^0	0.5^0	0.2^0	0.5^0
Entrance Angle – 86^0	0.20	0.15	0.15	0.10

4. Suitability for Application.

The marking film shall adhere to asphaltic concrete and Portland cement concrete surfaces when applied according to the manufacturer's recommendations at pavement surface and ambient air temperatures down to 50^0F (10^0C) when daily temperatures above 70^0F are prevailing to ensure film conformance and adherence to pavement surface. Following application the marking film shall be ready for traffic. Areas of minor damage may be readily patched with an inlay of this film in accordance with the manufacturer's recommendation.

5. Durability.

The marking film, when applied in accordance with the manufacturer's recommended procedures, shall provide a neat, durable marking maintaining the original design and configuration. Although the reflectivity will be reduced by wear, the film shall provide a cushioned resilient substrate to reduce bead crushing and loss. The film shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion. Applied

as recommended the marking film shall be expected to have an effective performance life, under normal conditions, of 3 years.

6. Packaging.

The pavement marking film as supplied shall be of good appearance, free of cracks, and the edges shall be clean cut and well defined. The film and contact cement shall be packaged in standard commercial containers in accordance with commercially accepted standards. These materials as supplied may be stored at normal temperatures for a period of one year after purchase.

F. Sheeting and Tape.

1. Type of Material.

This section covers reflectorized sheeting or tape materials processed into rolls of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement.

2. General Characteristics.

Reflectorized sheeting or tape shall consist of a white or yellow, weather and traffic resistant reflective film on a conformable backing precoated with a pressure sensitive adhesive. The adhesive shall be protected by a removable liner. Color shall be white or yellow as specified for pavement markings. The average thickness of the sheeting or tape shall be 0.03 inch.

3. Physical Requirements.

a. Reflectivity.

(1) The white and yellow sheeting or tape shall be retroreflective reflecting white or yellow respectively, shall be readily visible when viewed with automobile headlights at night, and shall have the following minimum reflective values at 0.2^0 and 0.5^0 divergence angles measured in accordance with the photometric testing procedures of Federal Specification LS-300A, “Sheeting & Tape, Reflective; Nonexposed Lens Adhesive Backing”, Para. 4.4.7 or as amended. Reflective values shall be expressed as candlepower per foot candle per square foot (candelas per lux per square meter) measured on a 5 sq. ft. panel (2-1/2 feet by 2 feet) at an 86^0 incidence angle. The 5 sq. ft. is derived from a standard stripe, defined as 4 inches by 15 feet = 5 square feet. From this the 2-1/2 feet x 2 feet panel used is for convenience in testing and comparison.

Reflectivity Value (candle power per foot candle per square foot)

	White		Yellow	
Divergence Angle	0.2^0	0.5^0	0.2^0	0.5^0
Incidence Angle 86^0	0.20	0.18	0.18	0.16

(2) A 2-1/2 feet x 2 feet panel, completely covered with either white or yellow pavement marking sheeting, shall be placed, reflective side up, in a horizontal pan sufficiently high above the pan side (or edge) so that the reflective pan shall be completely in view for measurement. The panel shall be tipped at an angle of 4^0 to the horizontal bottom of the pan for drainage. The entire panel shall be quickly flooded with clean water and allowed to drain. The minimum reflective value expressed as candlepower per foot candle per square foot shall be measured between 15 and 30 seconds after the panel starts to drain. The minimum reflective values shall be as follows:

Reflectivity Value (candle power per foot candle per square foot)

	White		Yellow	
Divergence Angle	0.2^0	0.5^0	0.2^0	0.5^0

Incidence Angle 86^0	0.10	0.09	0.09	0.08

b. Adhesive and Liner.

(1) The marking material shall have a precoated pressure sensitive adhesive and require no activation. The adhesive shall be protected, prior to application, with a removable liner to prevent contamination during processing, cutting, and handling. The liner shall release from the adhesive easily, without splitting or tearing, and shall not shrink or prematurely release from the adhesive during processing, storage or handling.

(2) Test pieces of the marking material shall be applied according to manufacturer's instructions and tested in accordance with ASTM D 1000, Method D, with two exceptions:

(a) A stiff, short bristle, roller type, tamper brush shall be substituted for the weighted rubber roller used to roll the test strips onto the metal test panel. The stiff, short bristles, shall be required to produce a tamping action between the beads to assure maximum contact of the marking material adhesive to the metal panel. Heavy pressure shall be exerted on the brush when rolling the sample.

(b) The beaded surface of the marking test pieces shall be covered with a thin tape not over 1 inch wide to prevent interference with or locking of the beads when the test piece is bent back 180^0 on itself for the adhesion test.

c. Application Properties.
The material shall adhere to asphalt and concrete surfaces when applied to manufacturer's recommendations at surface temperatures down to 35^0F (2^0C) and shall be immediately ready for traffic following application.

d. Conformability.
The marking material shall be thin, flexible, formable, and following application shall remain conformed to the texture of the pavement surface.

e. Thickness.
The average thickness of the material, excluding liner, shall be determined by taking 5 micrometer readings (using micrometer with approximately ¼ inch anvil and spindle) on a sample applied to an aluminum panel and deducting the thickness of the aluminum panel. The average thickness of 5 readings shall not be less than 20 mils nor more than 45 mils.

f. Removability.
Marking material shall be removable by following the manufacturer's recommendations, if the material is substantially intact. Removal shall not require sandblast, solvent or grinding methods and shall not result in objectionable staining of the pavement surface.

g. Durability and Wear Resistance.
The pavement marking material applied to asphalt or concrete in accordance with the manufacturer's recommended procedures shall be weather-resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line. Samples of material shall be applied to 4 inch by 4 inch test panels of 0.040" aluminum, (6061-T6 alloy), prepared according to recommendations of marking material manufacturer. The applied sample shall be tested in accordance with Federal Test Method Standard No. 141, Method 6192, using a CS-17 wheel and 1000 gram load and shall not wear through to the metallic surface in less than 5000 cycles. Care shall be taken to adjust the vacuum suction for the most effective removal of the abradings.

NOTE: Taber wheels used for this test shall have a "Shore A" Durometer hardness of

between 76 and 86 measured according to ASTM D 2240.

4. Packaging.

a. The pavement marking material as supplied shall be of good appearance, free from cracks, and edges will be true, straight and unbroken. The marking material shall be available in precut symbols and legends as specified and as roll goods up to 48 inches in width with no more than three splices per 50 yards of length.

b. The pavement material shall be packaged in accordance with accepted commercial standards and when stored under normal conditions shall be suitable for use for a period of at least on year after purchase.

G. Striping Powder.

1. Type of Material.
This section covers ready mixed powder products of application consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement with or without liquid road surface conditioner.

2. General Properties.

a. Description.
The striping powder shall be a free flowing plastic type pavement marking material which is premixed with glass spheres for reflectorization. When flame sprayed to clean portland cement concrete and asphaltic concrete pavement road surface by a suitable mechanical striper, the striping powder shall produce an instant dry to no pickup, adherent, reflectorized stripe capable of resisting deformation by traffic. A liquid may be desired for application to some road surfaces before application of the marking powder; if so, it shall be so stated on the request for bid.

b. Suitability to Application.

(1) The powder shall be suited to application by means of flame sprayed gun type pavement marking equipment used by the City of Memphis and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

(2) The liquid road surface conditioner shall be suited to application by pressure spray gun system or by conventional paint roller.

c. Physical Characteristics of Striping Powder.
The striping powder shall be a dry mixture capable of freely flowing through the flame spray marking equipment at the rate of 14 to 18 ounces per 30 seconds when exposed to combined conditions of humidity up to 90 percent relative humidity and ambient air temperature up to 100^0F. The striping powder shall require no thinning, mixing or heating prior to use and shall be satisfactorily usable at minimum road surface temperatures of 50^0F and minimum ambient air temperature of 60^0F.

d. Color.
The striping powder shall match the Federal Highway Administration color tolerance chart for standard highway yellow or standard highway white as required by the order. Color determinations shall be made on casts of samples melted at 200^0F and poured into aluminum foil weighting dishes of the following dimensions:

Rim diameter - 58mm

Height - 18mm

e. Particle Size.
The finished powder as supplied shall have the following grading:

U.S. Sieve No.	Percent by Weight Retained
30	0 - 2
230	93 - 100
Pan	0 - 5

f. Softening Point.
Tested in accordance with "ring and ball softening point determination" ASTM Test No. E 28, the softening point shall be from 215^0 to 225^0F.

g. Liquid Road Surface Conditioner.
The liquid, when specified, shall require no thinning, be easily applied, and be compatible with road surfaces and the marking powder supplied.

h. Glass Spheres.
The finished powder shall contain intermixed glass spheres.
NOTE: Representative finished powder samples, taken from a thoroughly mixed, full carton of finished powder, must be used for all glass sphere determinations.

(1) Index of refraction of glass spheres: 1.5 minimum; 1.6 maximum.

(2) Percent of weight of glass spheres: 30 percent minimum; 35 percent maximum.

Method of Determination of Percent by Weight of Glass Spheres:
- Equipment:
  - Laboratory triple beam balance.
  - U.S. standard screen (270) mesh.
  - 400 ml. glass beaker.
  - Oven at 200^0F.
- Procedure:
  - Weigh 100 grams of finished powder in 400 ml. beaker.
  - Add 200 ml. of suitable solvent (alcohol, aromatic solvent, or Ketone)
  - Pour solution on 270 mesh screen (flush beaker with solvent to remove all the beads).
  - Wash the beads on the screen with solvent until they are clear.
  - Dry in oven at 200^0F and weigh the amount of beads recovered.
  - Calculate percent of beads by:
    $\frac{\text{Wt. of Beans}}{\text{Wt. of Sample}} \times 100\% = \%$ of beads.

(3) Grading of glass spheres.

U.S. Sieve No.	Percent by Weight Retained
40	0 - 5
70	15 - 60
230	35 - 85
Pan	0 - 15

(4) Other Properties of Glass Spheres.
The properties of crushing resistance, roundness, index of refraction and chemical resistance shall be as required in Specification Section 02760 Paragraph 2.01 H.

3. Equipment.
Striping powder id designed for application by a light weight hand propelled striper as described in Specification Section 02760 Paragraph 2.02 D.

4. Packaging.
The finished powder shall be delivered ready for use and shall be packaged in 25 pound cartons or other acceptable containers clearly identified as to manufacturer, color, contents and quantity and shall be free of lumps, foreign particles or other matter. Cartons employed for packaging shall withstand normal handling and shall have a suitable protective interliner to resist moisture absorption. The powder, as supplied, may be stored at temperatures not to exceed 90^0F for up to one year, without adversely affecting the physical properties stated in this Specification. The liquid road surface conditioner, if required, shall be delivered ready for use in one gallon containers meeting current Interstate Commerce Commission requirements.

5. Properties of Applied Powder Line.
Dispensed and properly applied by flame spray gun type striper, the finished line shall be reflective and shall adhere so as to form a smooth continuous film on both portland cement concrete and asphaltic concrete road surfaces. Minor temporary line discoloration, due to surface soot, shall be permissible on adjacent overlapping lines. Lines exhibiting surface soot shall regain full color with traffic wear. A properly applied striping powder line shall not exhibit bleeding when applied on cured asphalt surfaces. An applied line shall dry to no pickup (10 mils application) when tested in accordance with ASTM Test No. D 711. Determination shall be made by averaging a minimum of 3 no-pickup readings at each pavement temperature tested. When the pavement temperature is between 50^0F and 90^0 F, drying time should be 10 seconds or less. When the pavement temperature is between 90^0F and 140^0F, drying time should be 25 seconds or less. Liquid road surface conditioner shall be easily applied by pressure spray gun or conventional paint roller with a solvent resistant sleeve with 7/16 inch nap. It shall be allowed to dry on the pavement surface for approximately 5 minutes prior to applying marking powder.

H. Glass Spheres For Reflectorization.
This section describes the general and specific requirements for glass beads to be applied with pavement marking paints and the physical properties of glass spheres to be applied with other binders to be used by the City.

1. Physical Properties for all Glass Spheres.

a. General.
Glass beads shall be clear, colorless, and clean, and of such character as to permit their embedment in a pigmented binder having their upper surface exposed to permit the refracting of light rays. The beads shall be bisymmetric bonding in that when applied to a paint, plastic, or polymer binder they shall hemispherically embed (to approximately their equator) in the binder film for maximum durability and brightness.

b. Crushing Resistance.
The crushing resistance of glass spheres shall be determined in accordance with ASTM D 1213. A 40 pound dead weight for 20 to 30 mesh spheres shall be the average resistance of the spheres tested.

c. Roundness.
The roundness of glass spheres shall be determined by ASTM D 1155. A maximum of 25 percent (by weight) shall contain irregular or fused sphered particles

d. Refractive Index.

The spheres shall have an average index of refraction not less than 1.50 nor more than 1.60 when tested by the liquid immersion method at 25^0C.

e. Chemical Resistance.
The glass spheres shall withstand immersion in water and acids without undergoing noticeable corrosion or etching and shall not be darkened or otherwise noticeably decomposed by sulfides. The tests for chemical resistance shall consist of one hour immersion in water and in solutions of corrosive agents followed by microscopic inspection. A 3 to 5 gram portion of the sample shall be placed in each of three Pyrex glass beakers or porcelain dishes; one sample shall be covered with distilled water, one with a 3N solution of sulfuric aced and the other with a 50 percent solution of sodium sulfide. After one hour of immersion, the glass spheres of each sample shall be examined microscopically for evidence of darkening and frosting.

NOTE: The tests described in United States Federal Specification TT-P-85b, items 4.4:13; 4.4:14; 4.4:15; and 4.4:16 may be substituted for the test described above.

f. Flow Properties.
The glass spheres shall flow freely through the dispensing equipment in any weather suitable for striping.

g. Color.
The glass spheres shall be colorless to the extent that they impart no off-color day or nighttime hue to the binder when applied at normal application rates.

2. Properties Of Glass Spheres For Use With Pavement Marking Paint.

a. Gradation.
A sieve analysis of glass spheres shall be made in accordance with ASTM D 1214. Required gradations are as follows:

(1) 5 to 20 percent passing #20; retained on #30 sieve.
(2) 30 to 75 percent passing #30; retained on 350 sieve.
(3) 9 to 32 percent passing #50; retained on #80 sieve.
(4) 0 to 10 percent passing #80 sieve.

b. Flotation.

(1) A minimum of 90 percent of the flotation glass spheres shall float on xylol (aromatic solvent) and a minimum of 75 percent shall float on heptane (aliphatic solvent) when tested as follows:

(2) A single layer of spheres shall be spread on the flat center of a clean inverted pint tin can lid. Solvent shall be slowly introduced with a syringe or dropper into the circular groove at the edge of the lid until it overflows into the center. The percentage of spheres floating on the solvent surface shall be estimated visually.

3. Gradation of Glass Spheres For Use With Plastic Pavement Marking Materials.
A sieve analysis of glass spheres should be made in accordance with ASTM D 1214. Gradations of glass spheres must be approved by the Owner for use with each plastic material. Typical gradations required for various types of plastic pavement marking materials are as follows:

a. To be included in hot thermoplastic material:
(1) 80 to 100 percent passing #60 sieve.
(2) 0 to 10 percent passing #140 sieve.

b. For application on molten thermoplastic material:

(1) 90 to 100 percent passing #20 sieve.
(2) 20 to 50 percent passing #50 sieve.
(3) 0 to 10 percent passing #80 sieve.

c. For cold thermoplastics and pliant polymer film:
(1) 100 percent passing #60 sieve.
(2) 0 to 15 percent passing #140 sieve.

4. Packaging.

The glass spheres shall be packaged in multiply paper, polyethelene, or burlap bags with a waterproof liner. The bags shall be strong enough to permit normal handling during shipment and transportation on the job without any loss of spheres and shall be sufficiently water resistant so that spheres will not become wet or caked during transit. The bags of glass spheres shall weigh a maximum of 60 lbs. each.

I. Raised Reflective Pavement Markers.

1. Classification.

Type 1, One Color, Reflective Markers (Two-way Traffic).
Type 2, One Color, Reflective Markers (One-way Traffic).
Type 3, Two Color, Reflective Markers (One-way Traffic).

2. Description.

Reflective pavement markers shall be of the prismatic reflector type, consisting of a high impact plastic shell filled with a mixture of inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one or two prismatic faces, molded to reflect incident light, from a single direction or from opposite directions. The shell shall be of one color or of a combination of two colors which will be the same as reflective elements and shall be of size and shape shown on the plans. The base of the marker shall be free from gloss or substances which may reduce its bond to the adhesive. The presence of a soft or resin film on the surface of the base will be cause for rejection.

3. Specific Intensity.

The specific intensity of each reflective surface, when tested at 0.2 degree angle of divergence, shall not be less than the following specified values:

	Clear	Yellow	Red
0^0 Incidence Angle -	3.0	1.5	0.75
20^0 Incidence Angel -	1.2	0.60	0.30

The following definitions and tests shall be applicable:

a. Angle of Incidence.

The angle formed by a ray from the light source to the marker, and the normal to the leading edge of the marker face.

b. Angle of Divergence.

The angle formed by a ray from the light source to the marker and the returned ray from the marker to the measuring receptor.

c. Specific Intensity.

The mean candle power of the reflected light at a given incidence and divergence angle for each foot candle at the reflector on a plane perpendicular to the incident light.

$$SI = R_L / I_L \times D^2$$

Where: SI = Specific Intensity
R_L = Reflected Light
I_L = Incident Light
D = Test Distance

d. Test Method.
The markers to be tested shall be located with the center of the reflecting face at a distance of 5 feet from a uniformly bright light source having an effective diameter of 0.2 inch. The photocell receptor width shall be 0.05 inch and shall be shielded to eliminate stray light. The distance from the center of the light source aperture to the center of the photocell shall be 0.21 inch. If a test distance of other than 5 feet is used, the source and receptor shall be modified in the same proportion as the test distance.

4. Color.
The color of the raised reflective pavement markers when illuminated by an automobile headlight shall be clear, yellow, or red as required. Off-color reflection shall constitute grounds for rejection.

5. Load Test.
The raised reflective pavement markers shall support a minimum load of 2,000 pounds applied in the following manner: A random sample of three markers shall be selected for the load test. The markers shall be centered base down over the open end of a vertically positioned hollowed metal cylinder. The cylinder shall be one inch high, with an internal diameter of 3 inches and a wall thickness of ¼ inch. A load necessary to test the marker shall be applied at a speed of 0.2 inch per minute to the top of the marker through a one inch diameter solid metal plug centered on the top of the marker. Failure shall consist of either (1) breakage or significant deformation of the marker at a load of less than 2,000 pounds; or(2) significant delaminating of the shell and the filler material regardless of the load required to break the marker.

6. Sampling and Tolerances.

a. Sampling.
Twenty markers selected at random will constitute a representative sample for each lot consisting of 10,000 markers or less. Forty markers will constitute a representative sample for lots consisting of more than 10,000 markers. The lot size shall not exceed 25,000 markers.

b. Tolerances.

(1) At least 90 percent of the original sampling of each lot of markers shall pass all tests except the strength tests. If less than 90 percent but more than 70 percent pass all tests, a resample of that lot will be allowed at the request of the Contractor. When less than 70 percent of the markers from the original sample comply with the requirements, the lot represented by the samples will be rejected and not resample will be allowed.

(2) Should any one of the 3 samples selected for strength testing fail to comply with the strength requirements of this Specification, 6 additional samples will be tested. The failure of any one of these 6 samples shall be cause for the rejection of the entire lot or shipment represented by the samples.

7. Packing And Shipping.
Shipments shall be made in containers which are acceptable to common carriers and packages in such a manner as to ensure delivery in perfect condition. Any damaged shipments shall be replaced by the Contractor. Each package of pavement markers shall be clearly marked as to name of the manufacturer, color, type, lot number, quantity enclosed, and date of manufacture.

J. Epoxy Adhesive For Pavement Markers.

1. General.

a. This Specification describes Type 1R epoxy adhesive (Rapid Setting Pavement Marker Adhesive) which is designed to bond plastic traffic markers to roadway and bridge surfaces. The adhesive is intended for mixing by automatic metering, mixing and application equipment. Rapid Setting Marker Adhesive must be used when pavement temperature is above 50^0F.

b. The adhesive shall be furnished in two components, herein referred to as Epoxy Resin Component and Hardener Component; the two components shall be mixed 1 to 1 by volume just prior to use.

2. Component Properties.

The manufacturer shall certify by lot number the following chemical properties as determined by the designated test methods.

a. Component Resin:

(1) Viscosity, Poises @ 77^0F.	ASTM D 445 Note (1)
(2) Epoxide Equivalent (Filled and also unfilled when applicable)	ASTM D 1652 Note (2)
(3) Volatiles, percent by weight distilled below 350^0F.	ASTM D 1078
(4) Ash Content percent by weight	ASTM D 482

b. Component Hardener.

(1) Viscosity, Poises @ 77^0F.	ASTM D 445 Note (1)
(2) Volatiles, percent by weight distilled below 350^0F.	ASTM D 1078
(3) Ash content percent by weight	ASTM D 482

Note (1) 400 ml. sample with Brookfield Viscometer, Model LVT with specified spindle rotating at specified speed.
Note (2) Grams of material containing 1 gram equivalent of epoxide (WPE).

c. Component Ratio.

The ration of Resin and Hardener components to be mixed together to form the finished adhesive shall be 1 to 1 by volume and the components will be packaged in the proper proportions.

d. Dispersion.

All pigments, fillers, and/or thixotropic agents present in either the Epoxy Resin or Hardener component must be sufficiently dispersed so that no appreciable separatin or settling will occur during storage.

e. Nonvolatile Components.

Each component of the adhesives shall be 100 percent nonvolatiles. A test for any volatiles shall be made.

f. Color Coding.

The components shall be color coded so that visual inspection will assure homogeneous mixing. The color will be subject to approval of the Owner.

3. Mixed Components – Physical Properties

The mixed marker adhesive shall comply with the following physical requirements when tested according to the methods which are available from the Owner.

Property	Requirements
Thixotrophy – Sag Test (Maximum)	.250 inches
Gel Time or Pot Life	7 – 12 minutes

Property	Requirements
Set time (to obtain a minimum strength of 180 psi) @ 77^0F or at temperature recommended by manufacturer:	40 minutes
Bond Strength (24 hours @ 77^0F) (Minimum)	250 psi
Property Retention – after 5 cycles 0^0F to 100^0F (Minimum)	98 percent

4. Packing and Marking.
The component resin and component hardener shall be delivered in the manufacturer's original clean, sealed containers. Each container shall bear a label with the following information shown thereon: The name and address of the manufacturer, designation (component resin or component hardener), date of manufacture, batch number (a batch shall consist of a single charge of all components in a mixing chamber), mixing instructions, a warning concerning toxicity and handling precautions.

5. Sampling.
A sample from each batch of each component shall be submitted to the City for testing. The sample shall be taken from the vendor's stock or from the shipment to the Contractor.

2.02 APPLICATION EQUIPMENT
All equipment required for the satisfactory performance of this Work shall be on hand and approved by the Owner before execution of the Work will be permitted to begin.

A. Painting Equipment.

1. Paint shall be applied by means of a machine of the spray type capable of satisfactorily applying the paint under pressure through a nozzle spraying directly upon the pavement. The machine shall be equip[ed with an air blast device for cleaning the pavement ahead of the painting operation, a guide pointer to keep the machine on an accurate line, and a device to agitate the paint. It shall also have a device to maintain a uniform flow and application of the paint, an automatic device to provide a broken or skip line of the length required, and a least 3 spray guns capable of being operated either individually or 2 or 3 together. The machine shall be equipped with a bead or sphere dispenser which can be regulated to dispense the spheres automatically at the uniform rate required. The equipment shall be so designed and operated as to permit traffic to pass on the roadbed with safety.

2. Each spray application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with a accuracy of 0.50%, to be checked by the Owner.

3. The equipment required for the application of conventional paints may range from simple hand or self-propelled stripers to relatively large truck mounted equipment. Paint heating equipment is not normally required for the application of this type material.

4. The application equipment for rapid dry paint shall be truck-mounted due to the pain heating equipment required. Rapid dry paints require heating to a maximum of 170^0F at the spray nozzle as recommended by the manufacturer.

B. Hot Plastic Application Equipment.

1. The equipment used to install hot extruded thermoplastic materials by contract under this Specification shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall prevent accumulation and clogging. All parts of the equipment which come in contact with the material shall be constructed for easy accessibility and exposure for cleaning and maintenance. The equipment shall operate so that all mixing and conveying parts, including the shaping die, maintain the material at the plastic temperature. The use of pans, aprons or similar appliances which the die overruns will not be permitted under this Specification. The equipment shall provide for varying die widths and to produce varying widths of traffic marking. The equipment shall permit preheating of the pavement immediately prior to application of the thermoplastic material if preheating is recommended by the thermoplastic manufacturer.

2. The equipment used to install hot extruded or spray thermoplastic materials by contract under this Specification shall be constructed so as to insure continuous uniformity in the dimensions of the stripe. The thickness of the material on the pavement shall be as specified on the Plans. The applicator shall provide a means for clearly cutting off square stripe ends and shall provide a means for applying “skip” lines. The equipment shall provide for varying widths of traffic markings. The applicator shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

3. Glass spheres applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine so that the beads are dispensed almost instantaneously upon the installed line. The glass sphere dispenser shall be equipped with an automatic cut-off control synchronized with the cut-off of the thermoplastic material.

4. A special kettle shall be provided for melting and heating the thermoplastic material. The kettle must be equipped with an automatic thermostatic control device for positive temperature control and to prevent overheating of the material. The heating kettle and applicator shall meet the requirements of the National Board of Fire Underwriters, of the National Fire Protection Association of the state and of the local authorities.

C. Cold Plastic Application Equipment.

Cold thermoplastics may be rolled into place with conventional pavement and highway rollers. Special equipment necessary for the successful installation of any cold thermoplastic shall be provided on a loan basis by the manufacturer of the thermoplastic material.

D. Striping Powder Application Equipment.

Striping powder is designed for application by a light weight hand propelled striper with a propane fired application gun. An external compressor capable of delivering 18 cfm at 70 psi is required for the system.

PART 3 - APPLICATION REQUIREMENTS

3.01 REFLECTIVE PAVEMENT MARKING PAINT.

A. Cleaning and painting shall be performed utilizing equipment of the kind and in the manner specified herein. On sections where no previously applied line is available to serve as a guide or if the line is to be relocated, the proposed location of the new line shall be spotted with paint in advance of the application. On tangent sections the control points shall be spaced no more than 500 feet apart and on curves at intervals that will insure the accurate location of the line. Gaps in all lines shall be left at intersections as shown in the MUTCD, or as directed.

B. No paint shall be applied over a chalk line, wire, or cord, but such guide marks shall offset the

paint line to be placed. On sections where previously applied lines are visible, the Contractor shall use the old lines unless otherwise directed. No paints shall be applied to areas of pavement when any moisture remains on the surface, or wind conditions are such as to cause a film of dust to be deposited on the line areas after these areas have been prepared for painting.

C. Paint shall be applied so as to deposit a uniform wet film thickness of 0.015 inches, which is at the rate of 16.5 gallons per mile for a solid stripe 4 inches wide, or as recommended by the manufacturer when approved in writing by the Owner. This rate of application shall apply to all types of paint, with proper adjustment made in gallons for an intermittent line or wider lines. The quantity of paint shall not underrun the designated amount by more than 5%, and if a check of the rate of application (are of line applied per unit volume of material) indicates a greater variation than this, the work shall be stopped until the paint machine is properly adjusted or replaced. This percent of variation is set out to give the contractor some leeway in starting the job and in getting his machine in adjustment but it is not expected that there shall be either a continuous overrun or underrun but that the final figures shall indicate that the average rate application closely approaches the rate established above.

D. Rapid dry (Type "B") paint shall be heated before application to a maximum of 170^0F at the spray nozzle or as recommended by the manufacturer.

E. Drop-on type glass beads shall be uniformly applied to the painted surface at a uniform rate of not less than six pounds per gallon of paint applied.

F. Protection of traffic lines and markings shall be provided by the Contractor. Warning and directional signs as shown on the Plans or as directed shall be placed to control traffic in the marking area. If the drying time of the material being used exceeds 60 seconds, the newly applied markings shall be protected by placing traffic cones or other approved warning devices at frequent intervals as directed. These devices shall be left on the line until the material is dry or firm enough not to track or receive impressions from normal traffic. They shall be removed as soon as possible (because of the traffic hazard) and shall never be left in the roadway overnight. If so directed, flaggers shall be provided to direct traffic.

G. The general appearance shall be that of clearly delineated lines with a minimum crooked and waving appearance, due consideration being given to the contours and roughness of the pavement. Segments of broken line strip shall square off positively at each end. The paint lines shall be without mist, drip or splatter. Lines that do not meet these requirements when placed shall be removed and/or corrected by the Contractor to the satisfaction of the Owner and without extra compensation.

H. The paint equipment shall be so operated that it will be unnecessary for traffic to cross the newly painted line behind the equipment in order to safely pass the painting machine, and traffic shall be allowed to keep moving at all times.

3.02 HOT THERMOPLASTICS.

A. The material shall be applied to the pavement by the spray method or by the extrusion method wherein one side of the shaping die is the pavement and the other three sides are contained by, or a part of, suitable equipment for heating and controlling the flow of material.

B. The material, when formed into traffic stripes, must be readily renewable by placing a thin overlay of new material directly over an old line of the same material. Such new material shall bond itself to the old line in such a manner that no splitting or separation takes place.

C. The finished lines shall have well-defined edges. The Contractor shall clean off dirt and grease where necessary by sand blasting or other approved methods.

D. A primer sealer of a type and if recommended by the manufacturer of the thermoplastic material shall be applied to the pavement surface prior to the installation of the thermoplastic material.

E. To insure optimum adhesion, the thermoplastic material shall be installed in a melted state at a temperature of 375^0 to 475^0F (190^0 – 246^0C).

F. Longitudinal lines shall be offset at least (2) inches (5cm) from construction joints of portland cement concrete pavements.

G. Openings of (6) inch (15cm) lengths shall be provided at (20) foot (6m) intervals in edge lines placed on the inside of superelevated curves to prevent the ponding of water on the pavement surface.

H. For non-defective pavement surfaces carrying volumes less than 50,000 vehicles per day, the contractor shall guarantee to replace or renew without cost to the City that part of the pavement markings installed which have not remained to perform useful service as follows:

1. Crosswalks and Stop Lines applied at a thickness of 125 mils (3.157mm): 75% of the total of any one intersection for one year

2. Lane Lines, Edge Lines and Center Lines applied at a thickness of 90 mils (2.286mm): 80% of a unit for one year and 60% of a unit for two years. (A "unit" is defined as any length of highway having installed thereon 2,000 lineal feet (610 m) of line of specified width in any combination or pattern). Warranties for thinner lines in these applications or for traffic volumes may be reduced commensurately.

3. The replacement material installed under this guarantee shall be guaranteed the same as the original material, from the date of the original installation.

Note 1: The intent is not to extend the original warranty period.
Note 2: The warranty does not cover those markings that have been removed by such devices as snow plows, chains, or studded tires.

3.03 COLD THERMOPLASTICS.

A. The cold thermoplastic material shall be applied to non-defective pavement surfaces that are free from dirt or other foreign matter. For normal application the pavement temperature shall be 60^0F or more. Application to be made at pavement temperatures below 60^0F shall be approved in writing by the Owner. Special instructions shall be supplied by the vendor for application to be made at pavement temperatures below 60^0F.

B. Adhesive, activators, or special coatings for various types of pavement surfaces provided with the thermoplastic material shall be installed according to the manufacturer's specifications. Cold plastics may be applied to new asphaltic pavement immediately prior to the final rolling of the new surface and rolled into place with conventional pavement and highway rollers.

C. Longitudinal lines shall be offset at least 2 inches from construction joints of portland cement concrete pavements. Openings of 6 inches length shall be left at 20 foot intervals in edge lines placed on the inside of superelevated curves so as to prevent the ponding of drainage of the pavement surface.

3.04 PLIANT POLYMER FILM.

The marking film shall be applied to asphaltic concrete and portland cement concrete surfaces according to the manufacturer's recommendations at pavement surface and ambient air temperatures 60^0F or more and when daily temperatures above 70^0F are prevailing to insure film conformance and adherence to pavement surface. Following application, the marking film is ready for traffic. Areas of minor damage shall be patched with an inlay of this film in accordance with the manufacturer's recommendation.

3.05 SHEETING AND TAPE.

Sheeting and tape material shall be applied directly to clean portland cement concrete and asphaltic concrete surfaces according to the manufacturer's recommendations at surface temperatures above 35^0F and shall be ready for traffic immediately following application.

3.06 STRIPING POWDER.

The powder shall be flame sprayed to clean portland cement concrete and asphaltic concrete to produce a solid, full width line of the required thickness. A liquid road surface conditioner may be required for application to some road surfaces before the application of the marking powder. Liquid road surface conditioner shall be applied by pressure spray gun system or by conventional paint roller.

3.07 RAISED REFLECTIVE PAVEMENT MARKERS.

A. Raised reflective pavement markers shall be cemented to the pavement with epoxy resin adhesive spaced as shown on the Plans. Markers shall not be installed over joints in rigid type pavements.

B. The portion of the highway surface to which the marker is attached by the adhesive shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers and any other material which would adversely affect the bond of the adhesive. Cleaning shall be done by sand blast cleaning on all pavement surfaces. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient t result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been pressed in place. All markers shall be cemented to the pavement within 10 minutes after the start of mixing of any one batch of adhesive. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker and all adhesive obscuring the reflective surface of the marker shall be immediately and completely removed with a clean, absorbent cloth. The use of thinners or solvents or any type for this purpose is prohibited. The marker shall be protected against impact until the adhesive has hardened to the degree designated by the Owner.

C. The specified adhesive requires that mixing operation and placing of the marker be done rapidly. The pot life of the adhesive may be prolonged by cooling after mixing the components or by spreading it out in a thin layer on a board before application. Any mixed batch of adhesive which becomes viscous because of its acquiring a partial set such that the marker cannot be pressed into place with the adhesive readily extruding from the edges shall not be used.

D. Immediately prior to mixing, each component of the adhesive (Package A and B) shall be thoroughly redispersed by stirring. Any material that cannot be readily redispersed shall be rejected. After redispersement, one volume from Package A shall be mixed with one volume from Package B until a uniform gray color without visible streaks of white or black is obtained.

E. When approved fast setting adhesive is used, the components shall be mixed by a 2 component type automatic mixing and extrusion apparatus, and the markers shall be placed immediately after the adhesive has been mixed and extruded.

3.08 REMOVAL OF PAINTED MARKINGS.

A. Painted pavement markings shall be removed where specified. The method used for paint removal shall be approved by the Owner prior to the beginning of the work. Removal of existing painted pavement markings by painting over with black paint or asphalt will not be allowed.

B. When the method of removal causes sand or other material to be accumulated on the pavement, the residue shall be removed as the work progresses. Painted markings shall be removed by methods that cause the least possible damage to the pavement. All damage to the pavement or surface caused by pavement marking removal shall be repaired as directed by the Owner at the

Contractor's expense.

C. Where a plastic marking will replace the painted marking, paint removal shall consist of removing enough paint to assure proper installation of the plastic. The paint removal shall be uniform and shall expose a minimum of 75 percent of the surface area that is to receive the plastic materials.

PART 4 – CERTIFICATION AND GUARANTEE

4.01 The Contractor shall furnish the Owner at, or before, the time of delivery, three copies of certification of conformance to the tests and requirements for traffic pavement marking materials of these Specifications. The certification shall consist of the following:

A. The name of the manufacturer of the material.

B. The batch or lot number of the material represented.

C. The test results of each required test.

D. A statement to the effect that a representative sample of the specific lot shipped has been tested and meets the requirements of these Specifications.

E. The name and title of the authorized representative of the manufacturer certifying to the correctness of the report.

F. The manufacturer shall guarantee the traffic pavement marking material supplied under these Specifications to meet all parts of these Specifications and shall agree to replace any amount of material found defective during inspection or installation of the material.

G. All replacement by the manufacturer shall be free of charge to the City, including all freight and handling charges. Material replaced under this guarantee shall, at the written request and expense of the manufacturer, be returned to the manufacturer by the City, unless said material has been installed.

PART 5 - MEASUREMENT

Accepted installed items related to pavement marking shall be measured in the units and as described herein. All work not described herein, included removal of existing pavement marking, shall be considered incidental to the installation of pavement markings and shall not be measured separately.

5.01 RAISED REFLECTIVE PAVEMENT MARKERS.
Accepted raised reflective pavement markers of each type shall be measured by the raised reflective pavement marker complete in place, per each.

5.02 PAINTED CURB.
Accepted curb painting shall be measured in linear feet to the nearest foot along the edge of the painted curb complete in place.

5.03 SOLID BARRIER LINE (4")
Accepted solid barrier lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.04 BROKEN LANE LINE (4")
Accepted broken lane lines shall b e measured in linear feet to the nearest foot along the center of each line including painted and unpainted portions complete in place.

5.05 DOUBLE SOLID BARRIER LINE (4")
Accepted double solid barrier lines shall be measured in linear feet to the nearest foot along the center of each pair of lines complete in place.

5.06 DOUBLE BROKEN BARRIER LINE (4")
Accepted double broken barrier lines for reversible lanes shall be measured in linear feet to the nearest foot along the center of each pair of lines including painted and unpainted portions complete in place.

5.07 DOUBLE BROKEN / SOLID BARRIER LINE (4")
Accepted double broken / solid barrier lines for restriction of passing in one direction or two-way left turn lanes shall be measured in linear feet to the nearest foot along the center of each pair of lines including painted and unpainted portions complete in place.

5.08 DOTTED LINE (4")
Accepted dotted lines for extension of lines through intersections shall be measured in linear feet to the nearest foot along the center of each marked dot complete in place.

5.09 SOLID BARRIER LINE (12")
Accepted solid barrier lines for channelization shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.10 CROSSWALK.
Accepted crosswalk lines shall be measured in linear feet to the nearest foot along the center of each line complete in place. The boundary lines shall be measured separately.

5.11 STOP LINE.
Accepted stop lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.12 TRANSVERSE SHOULDER LINES.
Accepted transverse shoulder lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.13 CHANNELIZATION.
Accepted pavement channelization marking complete in place shall be measured in square feet to the nearest square foot for the total area, marked and unmarked, to be channelized including boundary lines.

5.14 – 5.20 PAVEMENT MARKING (DESCRIPTION).
Accepted pavement marking (description) complete in place shall be measured as described on the Plans or in the Contract Documents.

5.21 STRAIGHT ARROW.
Accepted straight arrows shall be measured by the pavement arrow complete in place, per each.

5.22 TURN ARROW.
Accepted turn arrows shall be measured by the pavement arrow complete in place, per each.

5.23 STRAIGHT-TURN ARROW.
Accepted straight-turn arrows shall be measured by the pavement marking arrow complete in place, per each.

5.24 DOUBLE TURN ARROW.
Accepted double turn arrows shall be measured by the pavement marking arrow complete in place, per each.

5.25 PAVEMENT MARKING WORD "ONLY"
Accepted word "ONLY" pavement markings shall be measured by each pavement marking word complete in

place, per each work.

5.26 PAVEMENT MARKING WORD (DESCRIPTION).
Accepted pavement marking words as described on the Plans shall be measured by each pavement marking word complete in place, per each word.

5.27 PAVEMENT MARKING DESIGNS (DESCRIPTION).
Accepted pavement marking designs as described on the Plans shall be measured by each pavement marking design complete in place, per each design.

5.28 EXISTING STRIPING REMOVAL AS PER PLAN.
Accepted lane striping and pavement markings in place as per plan. Payment will be made for the work, completed and accepted by the Owner, at the contract lump sum price, which price shall be full compensation.

5.29 LANE STRIPING AND PAVEMENT MARKINGS IN PLACE AS PER PLAN.
Accepted removal of all existing striping as shown per plan. Payment will be made for the work, completed and accepted by the Owner, at the contract lump sum price, which price shall be full compensation.

PART 6 – PAYMENT

6.01 There is an allowance for this item. The unit price to be paid for pavement markings shall include the locating and layout of all pavement markings. The contract unit price shall be full compensation for accepted and installed pavement marking, complete in place, measured as described herein and shall include layout, materials, labor, equipment, tools, royalties, and other incidentals required to complete the work.

6.02 PAYMENT WILL BE MADE UNDER:

Item Number	Item Description	Pay unit
02760-5.01	TRAFFIC CALMING AND PAVEMENT MARKING ALLOWANCE	Lump Sum

END OF SECTION 02760