

SECTION 5 SANITARY SEWERS

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SECTION 5 SANITARY SEWERS

1.0 GENERAL REQUIREMENTS

1.1 DESCRIPTION. This section covers general construction requirements of sanitary sewers and sewer appurtenances as described herein.

1.2 PREQUALIFICATION. In the event that Prequalification Standards are required, the bidder of work performed under this specification shall be pre-qualified as Class "A" or "B" to perform such work. The Contractor must obtain all permits required by the City of Ardmore, State and federal regulations and laws.

1.3 CONSTRUCTION OUTSIDE CITY LIMITS. The Contractor performing work outside the corporate limits of Ardmore shall comply with all ordinances, regulations, and policies of the county and city wherein the work is located. He shall obtain any permits, provide barricades and lights, and make repairs as required by the responsible authorities.

1.4 TEST HOLES. Test hole information, when shown on the plans or included in the specifications, shall only represent subsurface characteristics to the extent indicated, and only for the point location of the test hole. Each bidder shall make his own interpretation of the character and condition of the materials that will be encountered between test hole locations. Each prospective Bidder may, at his own expense, make additional surveys and investigations as he may deem necessary to determine conditions which will affect performance of the work.

1.5 ORDER OF CONSTRUCTION. The Contractor shall start at enough different locations to complete the entire contract within the time limit specified. The construction of all sewers shall begin at the low point in the line in every case working toward the high point. When the construction involves the building of main or submain sewers having one or more lateral or tributary, the construction of tributary lines shall not be started until the main or submain sewer has been completed to the point where the tributaries or laterals discharge into it, except as may be approved by the Engineer. Approval by the Engineer does not relieve the Contractor of any responsibility for meeting the specified connections.

- Sewer appurtenances shall be constructed as soon as the sewer that they serve is constructed to their locations. The postponing of the construction of appurtenances until the sewer line has been completed, or the building of appurtenances in advance of the construction of the sewer line, will not be permitted.
- The construction of sewers 18-inches in diameter and smaller for more than 600 feet, and sewers 21-inches in diameter and larger for more than 300 feet in advance of appurtenances which are incomplete or the construction of which has not been started, will not be permitted.
- Unless otherwise directed by the Engineer, the Contractor shall leave no more than 900 feet between backfilling operations and the complete restoration of paving, paving repairs, fencing, sodding, etc. When temporary surfacing is provided for in the contract documents, the Contractor shall complete temporary paving repair immediately before backfill is completed.

1.6 MATERIALS.

1.6.1 Delivery. Construction materials shall not be delivered to the site of the work more than 3 days in advance of their anticipated use nor shall the quantity of pipe or other materials on hand at the site of the work at any time be in excess of the amount required to complete 300 feet of sewer unless with special permission of the Engineer.

1.6.2 Basic Material Parameters. Unless otherwise specified, all concrete used in construction of sewers and their appurtenances shall have a minimum 28-day compressive strength of not less than 3,500 psi and shall conform with the applicable requirements of the Materials Specification. All steel reinforcement used shall be Grade 60. The various pipes, fittings, and appurtenant structures shall meet or exceed the requirements as specified hereinbelow.

1.7 SEWER GRADES. The grade line shown on the plans is the elevation of the invert or flow line of the sewer. The sewer grade shall be established by use of laser beam, or other methods approved by the Engineer. When laser beams are used to establish line and grade, they shall first be calibrated in accordance with the equipment manufacturer's recommended procedures. The Contractor shall establish horizontal and vertical controls (offset stakes) with a transit or theodolite or any other equipment approved by the Engineer. The Contractor may then proceed to establish line and grade using the laser equipment. In conjunction with the laser beam, the Contractor may also be required to provide temporary benchmarks at intervals as specified by the Engineer.

1.8 STOPPERS OR BULKHEADS. Dead ends of all sewers, wyes, tees, etc., shall be closed with approved stoppers securely cemented in place. When shown on the plans or required by the Engineer, such openings shall be tightly walled up with brick masonry or concrete. Tight fitting stoppers or bulkheads shall be securely placed in or across the end of all sanitary sewer lines when construction is stopped at the end of each day's work or for any other cause. When work is stopped temporarily on sanitary sewers 24-inches in diameter and smaller, the exposed end of the pipe shall be closed to prevent trash or debris from entering the pipe. Such stoppers need not be watertight.

1.9 SURFACE DRAINAGE STRUCTURES. When not called for on the plans or specified as separate bid item, all surface drainage structures and appurtenances shall be removed and replaced in a condition equal to or better than the original installation when required. No additional compensation shall be made for this work, and the cost of same shall be included in "Site Clearing and Restoration" or the other pay items.

1.10 TEMPORARY SEWER AND DRAIN CONNECTIONS. When existing sewers have to be taken-up or removed, the Contractor at his own expense, shall provide and maintain temporary outlets and connections for all private or public drains, sewers or sewer inlets. He shall also take care of all sewage and drainage which will be received from these drains, sewers and sewer inlets; and for this purpose he shall provide and maintain at his own expense, adequate pumping facilities and temporary outlets or diversions. He shall construct such trough, pipe or other structures necessary and be prepared at all times to dispose of drainage and sewage received from these temporary connections until such time as the permanent connections are built and in service. The existing sewers and connections shall be kept in service and maintained under the contract, save where specified or ordered to be abandoned by the Engineer. All water or sewage shall be disposed of in a satisfactory manner so that no nuisance is created and that the work under construction will be adequately protected.

1.11 CLEANUP. After installation of each section of sewer line, the Contractor shall remove all spoils resulting from work, debris, construction materials and equipment from the site of work, grade, and smooth over surfaces on both sides of the line, and leave the right-of-way in a clean, neat, and serviceable condition prior to sodding.

2.0 PIPE INSTALLATION.

2.1 DESCRIPTION. This section covers installation of pipes in open-cuts, in conformity with the lines, grades, and dimensions and as provided in applicable sections of these specifications.

2.2 PIPE MATERIALS

2.2.1 PIPE

Acceptable pipe materials and fittings shall meet the requirements of the appropriate sections listed below:

Pipe Type	Pipe Material	Paragraph
Rigid	Reinforced Concrete Pipe (RCP)	647
	Vitrified Clay Pipe (VCP)	649
Flexible	Ductile-Iron Pipe (DIP)	650
	High Density Polyethylene (HDPE) Pipe	651
	Polyvinyl Chloride (PVC) Pipe	652
	Reinforced Fiberglass Pipe (RFP)	653

2.2.2 EMBEDMENT AND BACKFILL MATERIAL. Embedment and backfill material shall meet the requirements of the Standard Drawings. Prior to delivery, the Contractor shall submit laboratory tests for materials to be used for embedment and backfill. The Engineer prior to placement shall approve materials. Where required, the Contractor shall submit invoices for the purpose of complying with the minimum quantities necessary to complete installation pursuant to the appropriate standard details and the minimum dimensions specified.

2.3 CONSTRUCTION METHODS

2.3.1 Bedding, Haunching, and Backfilling.

- Rigid Pipes. All rigid pipes shall be embedded in accordance with ASCE Manual No. 60, "Gravity Sanitary Sewer Design and Construction", Class "B" Bedding and in accordance with the dimensions and lines shown on the "Standard Detail for Installation of Rigid Pipes".
- Flexible Pipes. All flexible pipes shall be embedded in accordance with ASTM D2321, "Standard Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe", and in accordance with the dimensions and lines shown on the "Standard Detail for Installation of Flexible Pipes".

2.3.2 Installation Requirements.

- Shipping, Handling and Storage. Pipe shall be transported from the plant, where it is manufactured, to the job site employing special methods of packaging to prevent damage to the pipe. After the pipe is received at the job site, it shall be carefully inspected for any damage that may have occurred in transit. The pipe shall be handled at all times with care using padded slings or hooks. The pipe shall not be dropped, skidded or rolled against pipe already on the ground. If any damage occurs to pipe, the pipe shall be rejected. All pipe and accessories shall be stored on flat, level ground with no rocks or other objects under the pipe. Gaskets for push-on joints and pipe shall be stored in cool location out of direct sunlight in accordance with the manufacturer's recommendations.
- Quality of Work. Watertight joints, first grade material and accurate construction shall be required. Furthermore, utmost care shall be exercised in laying pipe to line and grade, constructing inverts in manholes, transitions, drop manhole connections and etc.
- Pipe Foundation. No sewer shall be laid unless the foundation is in a condition satisfactory to the Engineer. Where trenches are excavated in soft, unsuitable soil, or rock, trench bottom shall be stabilized as approved or directed by the Engineer.
- Laying Requirements. All pipes, specials, fittings and other appurtenances shall be examined carefully for damage and other defects before installation. The City retains the right to reject damaged and defective materials. The pipe ends shall be free of all lumps, blisters and they shall be wiped clean of foreign materials such as dirt and sand before installation. Pipe laying shall proceed upgrade, starting at the lower end of the grade and with the bells uphill, using laser beams or other methods approved by the Engineer. Bell holes for bell-and-spigot pipe shall be excavated at proper intervals so that the barrel of the pipe will rest for its entire length upon the bottom of the trench. Bell holes shall be large enough to permit proper installation of pipe and shall not be excavated more than 10 joints ahead of pipe laying. Filling and ramming earth or other material beneath the pipe to raise it to grade shall not be permitted. The Contractor shall use every precaution at all times during construction of the pipeline; all pipe, specials, fittings, and other appurtenances shall be lowered carefully into the trench with suitable equipment, to prevent damage to the sewer main materials. In rock trenches, plywood shields or other approved means shall be used to prevent the cradled pipe from swinging against the sides of the trench.
- Joints. All joint preparation and joining operations shall comply with the instructions and recommendations of the pipe manufacturer and meet the joint requirements in the appropriate material section. For reinforced concrete pipe the position of the rubber gasket shall be checked with a feeler after each joint is completed. Additionally, when laying reinforced concrete pipe, the maximum joint opening shall not exceed 1/2-inch. Rubber gaskets shall be positioned on the joint in accordance with the manufacturer's recommendations. Immediately before joints are pushed together, all joint surfaces shall be coated with the lubricant furnished with the pipe. Any damage to the pipe, from any cause during installation of the pipeline shall be cause for replacement, as directed by the Engineer, and at the expense of the Contractor.
- Section Completion. After a section of pipe is properly installed it shall be approved by the Engineer or Inspector prior to backfill and compaction.

2.4 METHOD OF MEASUREMENT. Payment for "Sanitary Sewer Pipe" shall be made at the unit price bid per lineal foot of pipe installed for each size. The price established shall be full compensation for all materials including pipe, material, labor, tools, equipment and incidentals necessary to complete this item of work. Payment shall not include the cost of trench excavation and backfill nor foundation material. Measurement for "Sanitary Sewer Pipe" shall be from station to station through manholes, junction boxes and other small structures.

2.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SANITARY SEWER PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the pipe installation work in accordance with these specifications.

3.0 SEWER SERVICE CONNECTION

3.1 DESCRIPTION. This section covers construction of sewer service connections where called for on the plans or as directed by the Engineer.

3.2 MATERIALS

3.2.1 PIPE MATERIALS. Acceptable pipe materials and fittings shall meet the requirements of the appropriate sections listed below:

Pipe Type	Pipe Material	Paragraph
Rigid	Vitrified Clay Pipe (VCP)	
Flexible	Ductile-Iron Pipe (DIP)*	
	Polyvinyl Chloride (PVC) Pipe	

3.2.2 CONNECTIONS. The following connections may be used to make sewer service connections:

- Wye Branches for External Connection for New Construction. For new construction there shall be installed wye branches of size and type shown on the plans with a minimum of 4-inch openings.
- External Saddle Connections to Existing Main. Connections may be made by excavating to the existing main and cutting a hole using approved equipment and installing a saddle. When existing main has been rehabilitated by a trenchless method of construction, the saddle connection shall be made to the trenchless pipe and/or liner.
- External Tee Connections to Existing Main. Connections may be made by removing a section of the existing pipe and installing a tee.
- Wye Branches - Connections may be made by removing a section of the existing pipe and installing a wye branch.
- Fittings, riser, and closure assembly shall be used to make the connection and shall be

supplied in a nominal diameter a minimum of 4-inches. The external connections shall be considered complete when backfilling and subsequent surface restoration is completed.

- Internal Connections (Reinstatements). Shall not be allowed.

3.2.3 RISERS.

- General. Risers shall be connected to sewer pipe using standard wyes, tees or saddles. No services may be connected to sewer pipe that is 18-inches and larger in diameter unless directed by the Engineer. The concrete encasement support and collar shall be required in all cases and constructed in accordance with the following schedule:

Pipe Nominal Size (inches)	Depth of Encasement (feet)	Width of Encasement (feet)	Length of Encasement (feet)
8	1.5	2.2	2.0
10	2.0	2.2	2.0
12	2.0	2.2	2.0
15	2.5	2.6	2.0
18	3.0	3.0	2.5

- Construction. Particular care shall be exercised in cutting the sewer pipe so that no damage is done to the pipe and its strength impaired by shattering or cracking of the pipe wall. The end of the fitting shall not protrude beyond the inside surface of the sewer main. The annular space around the fitting shall be completely filled and smoothly finished with Class "C" mortar with Type II cement. The backfill shall be thoroughly compacted under and above the pipe in the main sewer trench and up to at least the top of the concrete riser support. The backfill around the vertical pipe shall be carefully placed and tamped avoiding disturbance of the alignment of the pipe and damage to the joints. The vertical pipe shall be anchored to sewer trench wall with 1/4-inch round hairpin bars.
- Locator Tape. A locator tape, green in color, and stating "CAUTION--SANITARY SEWER RISER PIPE BURIED BELOW" shall be attached to the sanitary sewer riser and extend to a minimum of 2 feet above ground. The tape shall be 3-inch width DuraTec as manufactured by THOR Enterprises, Inc. of Sun Prairie, Wisconsin or approved equal.

3.3 CONSTRUCTION METHODS. All work shall be constructed in accordance with the "Standard Detail for Sanitary Sewer Connection". Unless otherwise specified, sanitary sewer connections shall be installed so that a plane through the center of the branch and the centerline of the main sewer shall make an angle of 45° with the horizontal. Place 1 cubic foot of concrete around each connection, the cost of which shall be included in other items. Sewer Service Connections constructed with wye branches shall include a 1/8° degree bend, elbow, and when required, a closure piece. Sewer Service Connections constructed with tees shall include a 1/8° degree bend, and when required, an elbow and a closure piece. Connections with saddles shall include straps, a 1/8° degree bend, and a closure piece.

3.4 METHOD OF MEASUREMENT. Payment for "Sewer Service Connection" shall be made at the unit price bid for each external connection. The price established shall be full compensation for all material, labor, equipment, trench excavation, backfill, and incidentals necessary to complete this item of work.

- When external sewer service connections are made in conjunction with installation of Formed-In-Placed Pipe (FIPP) per said section below, payment for external sewer connection shall be made at the unit price bid for each "Point Repair" regardless of depth.
- External connection (reinstatement) of services shall be considered incidental to the lining process and the cost shall be included in other items. The price established for "Point Repair" shall be full compensation for all material, labor, equipment, trench excavation, backfill, and incidentals necessary to complete this item of work.
- Payment for "Riser Pipe" shall be made at the unit price bid per lineal foot of pipe for new sewer construction. The price established shall be full compensation for materials, labor, tools, equipment and incidentals necessary to complete this item of work. Payment for "Riser Pipe" for replacement and/or rehabilitative sewer construction shall not be made directly but shall be included in the cost for "Sewer Service Line".

3.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SEWER SERVICE CONNECTION	EA
RISER PIPE	LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

4.0 SEWER SERVICE LINE

4.1 DESCRIPTION. This section covers service lines for future or existing connections. The service line shall be installed to a point where an acceptable connection can be made to the existing service if necessary. Pipe shall be supplied in nominal diameter a minimum of 4-inches.

4.2 MATERIALS. Acceptable pipe materials and fittings shall meet the requirements of the appropriate sections listed below:

Pipe Type	Pipe Material	Paragraph
Rigid	Vitrified Clay Pipe (VCP)	
Flexible	Ductile-Iron Pipe (DIP)	
	Polyvinyl Chloride (PVC) Pipe	

4.3 CONSTRUCTION METHODS. The installation of a service line includes removing any cap or plug from existing riser, cutting and removing any existing service line, and reconnecting the riser and the existing service line if necessary.

4.4 METHOD OF MEASUREMENT. Payment for "Sewer Service Line" shall be made at the unit price bid per lineal foot of pipe, including closure piece, and when required, adapters and other fittings. The price established shall be full compensation for all material, labor, tools, equipment and incidentals necessary to complete this item of work.

4.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SEWER SERVICE LINE LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

5.0 ABANDONING SEWER.

5.1 DESCRIPTION. This section covers filling of abandoned sewer lines with grout or concrete.

5.2 MATERIALS. The materials shall meet the requirements "Flowable Fill Plugs".

5.3 METHOD OF MEASUREMENT. Payment for "Abandoning Sewer" shall be made at the unit price bid per cubic yard. The price established shall be full compensation for furnishing and placing all materials, labor, tools, equipment and incidentals necessary to complete this item of work.

5.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

ABANDONING SEWER CY

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

6.0 PIPE BURSTING

6.1 DESCRIPTION. This section covers furnishing and installation of pipe by trenchless method of bursting existing pipes as shown on the plans and in conformity with these specifications. The operation shall be conducted with a hydraulic pulling or pushing apparatus and a pipe expander (i.e. pig and swab). The pipe expander shall be pushed or pulled through the existing pipe on grade, widening the existing pipe material for insertion of the new pipe material.

6.2 MATERIALS

6.2.1 Submittals. The Contractor shall furnish for the Engineer's approval, a plan showing his proposed method of handling, including the design for the equipment, equipment support of backstop, arrangement and position of jacks, pipe guides, etc., complete in assembled position. The approval of this plan by the Engineer will not relieve the Contractor from his responsibility to obtain the specified results.

6.2.2 Pipe. Acceptable pipe materials and fittings, high density polyethylene pipe and polyvinyl chloride pipe shall meet the requirements of the appropriate sections hereinbelow.

6.3 CONSTRUCTION METHODS

6.3.1 General. Where pipe is required to be installed under highways, streets or railroad embankments or other facilities by trenchless methods, construction shall be made in such a manner that will not interfere with the operation of those facilities and not weaken or damage any

embankment or structure. During construction operations, barricades and lights to safeguard traffic and pedestrians shall be furnished and maintained, as directed by the Engineer.

- The Contractor shall take proper precautions to avoid excavating earth or rock or shattering rock beyond the limits of excavation shown on the plans. All damages caused by excavating or blasting, either to surface or subsurface structures, shall be repaired or replaced by the Contractor at his own cost and expense. Suitable pit shafts, or trenches shall be excavated for the purpose of conducting the trenchless operations and for placing end joints of the pipe.
- Wherever end trenches are cut in the sides of the embankment or beyond it, such work shall be sheeted securely and braced in a manner satisfactory to the Engineer to prevent earth caving.
- The removal of any obstruction that may be found to conflict with the placing of the pipe shall not be measured for payment nor paid for as a separate contract pay item. The removal of any such obstruction shall be included in the cost of other items.
- Once the pipe installation has commenced it shall be continued uninterrupted around the clock until the pipe has been installed between the specified limits. Any pipe damaged during operations shall be removed and replaced by the contractor at his expense. The pits or trenches excavated to facilitate the operations shall be backfilled immediately after the pipe has been installed.

6.3.2 Sewer Service Connections. All sewer service connections required during pipebursting shall be accomplished and paid for in accordance with these specifications for same.

6.4 METHOD OF MEASUREMENT. "Pipe Bursting" shall be measured by the lineal foot of pipe completed. Payment for "Pipe Bursting" shall be made at the unit price bid per lineal foot of pipe for each size. The price established shall be full compensation for all materials, including pipe, labor, tools, equipment and incidentals necessary to complete this item of work.

6.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

PIPE BURSTING (SIZE)	LF
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Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

7.0 SLIPLINING

7.1 DESCRIPTION. This section covers rehabilitation of deteriorated sewer lines by trenchless method of sliding a liner pipe of smaller diameter into an existing circular pipeline, then if required, re-establishing service connections to the new liner pipe.

7.2 MATERIALS

7.2.1 Submittals. The Contractor shall submit source of materials for the specified liner pipe, or proposed liner pipe when alternate materials are specified. No liner pipe shall be shipped to job

site until all submittals have been reviewed and approved by the Engineer. Provide:

- Construction and Laying Schedule. The Contractor shall submit an area map of the project designating the beginning and ending points as well as complete pipe laying and time schedule and detail drawings. The map shall also indicate the access points, length, and pipes to be installed. Unless surveyed plans accompany the project specifications, all elevations shall be determined and included in the Schedule. This shall include verification of all elevations on as-built drawings when such information is provided. No pipe, special sections and fittings shall be manufactured until all submittals have been reviewed and approved by the Engineer. The drawings and data shall include but not be limited to the following for each size and class of pipe.
- Details of the proposed pipe, properties, strengths, components; and
- Details of joints
- A signed Certificate of Material Compliance letter from the manufacturer stating that all material satisfies claims made by the manufacturer and meets the requirements specified.
- Reports of the plant tests including, but not limited to, liner thickness, flexural strength, and flexural modulus shall be submitted. A licensed Engineer or manufacturer's quality assurance officer shall certify submittals.
- The location and number of insertion or access pits shall be planned by the Contractor and submitted in writing for approval by the Engineer prior to excavation. The pits shall be located such that their total number shall be minimized, and the footage of liner pipe installed in a single pull shall be maximized. Locations of damaged pipe shall be used for insertion pits as directed by the Engineer.
- The Contractor shall submit proposed sealing compounds to be used for sealing liner pipe at the manholes and type of grout and grouting equipment to be used.
- The Contractor shall submit a complete record of all jacking loads for the insertion of the pipe liner. This information shall be submitted to the Engineer for review after each insertion operation.
- The Contractor shall submit 6 copies of all submittals requested in these specifications.

7.2.2 Liner Pipe Materials. Acceptable liner pipe materials are as follows and shall meet the requirements of the appropriate sections following herein.

7.3 CONSTRUCTION METHODS

7.3.1 Cleaning sewer lines, sewer flow control, and point repairs shall be accomplished in accordance with the applicable sections hereinbelow provided. Segments between 2 consecutive manholes that require more than 4 point repairs for successful rehabilitation may be deleted, by the Engineer, from the specified work and these segments replaced by conventional excavation in accordance.

7.3.2 Inspection or Access Pit Excavation and Backfill. Before excavation is begun, it shall be the

responsibility of the Contractor to check with the various utility companies and determine the location of the utilities in the vicinity of the work area. The Contractor at no cost to the City shall arrange temporary construction easements, right-of-way areas or temporary access agreements where none are otherwise shown on the plans.

7.3.3 Excavations. All excavations shall be properly sheeted and shored in accordance with relevant specifications for trench safety systems. Any damage resulting from improperly shored excavations shall be corrected to the satisfaction of the Engineer with no compensation due to the Contractor. All open excavations shall be kept secure at all times by the use of barricades with appropriate lights and signs, construction tape, covering with steel plates, etc., or as directed by the Engineer. The cost for diversion pumping required around an insertion pit, from a manhole upstream to a manhole downstream, shall be per applicable item of these specifications. Excavations initially begun as Point Repairs that, for convenience, are later used as Insertion Pits, shall be treated as incidental to sliplining. If the point repair excavation is used as an insertion pit, the Contractor shall not be required to replace the carrier pipe.

7.3.4 Liner Pipe Insertion. The insertion and installation of the liner pipe shall be in accordance with appropriate ASTM Standard Specifications and the Manufacturer's Recommendations.

- The liner pipe shall be aligned in contact with the invert of the existing sewer. If more than one-third (1/3) of the top profile of the existing sanitary sewer line is not intact and cavities exist above the pipe, the condition of the sewer line shall be considered unsuitable and the sliplining operation shall not be performed.
- The Contractor shall maintain sewage flow at all times. This may be accomplished by allowing flows to pass through the liner pipe. By-pass pumping may also be allowed.
- Liner pipe shall not be installed prior to the Engineer's approval. The liner pipe shall be jacked, pushed or pulled, in case of a butt-welded polyethylene liner pipe (with no exceptions), into the existing pipe. An aqueous solution of Bentonite may be used to minimize the jacking load.
- For each section to be lined, insertion shall be one continuous operation until the planned termination point is reached. Precautionary measures shall be taken to ensure against scarring the liner or breaking the joints; use a nose-cone to guide the pipe end past minor obstructions and prevent entry of debris and put guards over the edges of the existing pipe at the inlet end to prevent their gouging the pipe during the insertion procedure. Once the insertion is initiated, it shall continue to completion without interruption.
- Total jacking loads shall not exceed the manufacturer's recommendations. The Contractor shall provide a suitable means of measuring jacking loads, and shall monitor the load as the liner pipe is being installed. If at any time the load appears to rise non-uniformly, indicating possible obstruction of the pipe, jacking operations shall be terminated and the obstruction or other impediment removed before continuing.
- Permanent bends to accommodate line or grade changes shall be limited to radii equivalent to a longitudinal strain recommended by the pipe manufacturer. At no time shall this minimum allowable radius of curvature be exceeded.
- The Engineer shall approve equipment employed in the sliplining process. An hydraulic or

cable operated winching pipe pushing device may be used. The machine operator shall closely and continuously monitor and control the jacking load in uniformity and magnitude. A jacking ring or device shall be used to distribute the jacking load evenly over the entire surface perimeter of the pipe end. The Contractor shall also utilize a device that holds a nearly inserted joint stable so as to prevent damage to it while the following joint is shoved home.

- All joint operations shall be made in full view of the inspector. The maximum pulling length recommended by the manufacturer shall not be exceeded. After insertion, the pipe shall be allowed to normalize for the number of hours suggested by the pipe manufacturer to the temperature of the ground as well as recover any imposed strain before cutting the pipe to length between manholes.

7.3.5 Liner Pipe Sealing. The annular space between the liner and the existing sewer main must be sealed at each manhole with a chemical seal and non-shrink grout. Oakum soaked in Scotchseal 6500, 3M Elastomeric Compound (CR-202), or approved equal, shall be placed in a band to form an effective watertight gasket in the annular space between the liner and the existing pipes in the manholes. The width of the band shall be a minimum of 12-inches. It shall be finished off with a non-shrink grout placed around the annular space from inside the manhole and shall not be less than 6-inches wide. The Engineer shall approve the chosen method, including chemicals and materials.

- The Contractor shall cut the liner so that it extends 4-inches into the manhole. The Contractor shall make a smooth, vertical cut and slope the area over the top of the exposed liner using non-shrink grout. The Contractor shall also use cementitious grout to form a smooth transition with a reshaped invert and a raised manhole bench such that neither the sharp edges of the liner pipe, nor the concrete bench, nor the channeled invert shall exist to catch debris and create a stoppage.
- The invert of the manhole shall also be reworked (smoothed and built-up) to match the flow line of the new liner.
- The liner pipe shall be allowed to normalize to ambient temperatures as well as recover from any imposed strain, in accordance with the manufacturer's recommendation before being cut to fit between manholes and proceeding with reshaping and/or smoothing the manhole invert.

7.3.6 Liner Pipe Grouting. The annular space between the liner pipe and the existing pipe shall be sealed with a grout having good flow characteristics, minimum shrinkage, and permanence of support such as Haliburton's LG-3 or approved equal system.

- A minimum 28-day compressive strength of the grout of 1,000 psi or greater shall be required to assure the structural integrity of the rehabilitated pipe. The safe grouting pressure shall conform to the type and the requirements of the pipe used. The maximum grouting pressure shall be in accordance with the liner pipe manufacturer's recommendations.
- The sealing compound shall be suitable for underwater application and have elastomeric properties. The annular space shall be 100% filled, but particular attention must be paid to those areas just downstream of manholes to avoid air traps. Equipment

for placement of grout shall be used so as to prevent segregation of the grout components and to cause the grout to flow around the liner and completely fill the voids in the annular space. Under no circumstances shall grout be dropped down the shafts onto the liner. Grout shall not be permitted to rise in the vertical shafts more than 2 feet above the top of the existing pipe. The Contractor shall have operable vibrators on the job to aid the flow of the grout. The Contractor shall have operable pumps on the job site to remove water from the vertical shafts as it is displaced by grout to prevent an excessive hydrostatic head on the liner. Pumping pressures during the grouting process must not exceed the collapse pressure of the liner pipe. The Contractor shall install a vent pipe higher than the upper end of the pipe to ensure that the annulus is completely filled with grout.

7.3.7 Testing. Television inspection, Smoke testing, Dye-water testing, and Sewer Leakage testing and sewer service connections shall be required after liner has been installed and prior to services being re-connected. These elements of testing shall be conducted in accordance with these specifications.

7.3.8 Acceptance of Sliplining. Final acceptance of sliplining shall be based on, but not be limited to, review of post-television inspection, leakage testing, and conformance with all provisions of these specifications as determined by the Engineer. The installed liner pipe shall be watertight, smooth, and free from wrinkles, as well as defects, and improper house connections. Should any of these defects occur, the line shall be excavated, repaired and/or replaced, and complete restoration shall be made to the satisfaction of the Engineer at no additional cost to the City.

7.4 METHOD OF MEASUREMENT. "Sliplining" shall be measured along the pipe, through manholes, junction boxes, and other small structures. Payment for "Sliplining" shall be made at the unit price bid per lineal foot of line, for each size installed and shall include liner pipe, grout for pipe sizes 15-inches and smaller, and buildup, shaping and reworking the manhole invert, and sealing the annular space, equipment, labor, tools, and incidentals necessary to complete this item of work. The addition of inverts/benches, if none already exist, shall be considered incidental to the cost of "Sliplining". The cost of grouting shall be incidental to sliplining for pipes 15-inches and smaller in size. For larger pipes, "Grouting" shall be paid for at the unit price bid per cubic yard. The price established shall be full compensation for all materials including grout, placement of grout, labor, tools, equipment and incidentals necessary to complete this item of work.

7.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SLIPLINING (SIZE)	LF
GROUTING	CY

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

8.0 FORMED-IN-PLACE PIPE (FIPP)

8.1 DESCRIPTION. This section covers rehabilitation of existing deteriorated sewers by trenchless method of installing formed-in-place pipe (FIPP) as hereafter described.

8.2 MATERIALS

8.2.1 Submittals. The Contractor shall submit source of materials for the specified liner pipe, or proposed liner pipe when alternate materials are specified. No FIPP shall be shipped to job site until all submittals have been reviewed and approved by the Engineer.

- Construction Schedule. The Contractor shall submit an area map of the project designating the beginning and ending points as well as the time frames for each inversion or insertion. The map shall also indicate the access manholes, length, and FIPP thickness to be installed for said inversions and/or insertion runs. Unless surveyed Plans accompany project specifications, all elevations shall be determined and included in the Construction Schedule. This shall include verification of all elevations on as-built drawings when such information is provided.
- Certification of Material Compliance. A signed letter from the manufacturer stating that FIPP meets the requirements of these specifications. The Contractor/manufacturer shall submit Type "A" and "D" certifications for the material.
- Quality Control Reports. The manufacturer's results of quality control tests performed on the actual material used. The reports shall contain all the raw data and intermediate calculations, as well as the testing procedures.
- Installation Manual. The Contractor shall submit installation manual describing the method of installation.
- Copies - The Contractor shall submit 6 copies of all submittals requested in these specifications.

8.2.2 FIPP Materials. Acceptable FIPP materials shall meet the requirements of the appropriate sections herein presented (for Deformed HDPE, Folded PVC, and Resin Impregnated Tube (i.e., Cured-in-Place Pipe).

8.2.3 FIPP Design Basis. The minimum installed formed-in-place pipe material thickness(es) specified are determined based on the buckling requirements (equation #3) established in ASTM F1216, Appendix X1, Design Consideration, Section X1.2.2 Fully Deteriorated Gravity Pipe Condition. The following design assumptions are used in determining the specified minimum thickness(es) for the acceptable FIPP materials:

Design Parameter	Design Assumption
Mean inside diameter of original pipe, D	Same as pipe nominal diameter
Soil unit Weight,	120 lb/ft ³
Height of soil above pipe, H	Minimum of 10 feet
Height of water above pipe, H _w	Same as height of soil above top of pipe
Live Load, W _l	AASHTO H20
Water Buoyancy Factor R _w	0.67
Total External Load, Q _t	Hydrostatic +R _w (earth prism load)+Live Load
Ovality of Original Pipe, q	2%
Safety Factor, N	2.00
Modulus of Soil Reaction, E's	700 psi

8.3 CONSTRUCTION METHODS

8.3.1 The installation of formed-in-place pipe shall be in accordance with appropriate ASTM Standard Specifications and the Manufacturer's recommendations. If no ASTM Standard exists for the installation, the licensor/manufacturer shall furnish, in detail, step-by-step procedures for review and approval by the Engineer.

- Temperatures and pressures shall be monitored and recorded throughout the installation process to ensure that each phase of the process is achieved at the approved manufacturers recommended temperature and pressure levels. When requested by the Engineer, the Contractor shall submit field records of temperatures, pressures, and other pertinent information regarding installation.
- The minimum span for the FIPP shall be the distance from inlet to outlet of the respective manholes unless approval to do otherwise is given by the Engineer. Individual runs can be made over one or more manhole sections, but shall not exceed manufacturer's recommendations for maximum allowable tension during the pulling process. Care shall also be taken to cut each end of the formed-in-place pipe as directed by the manufacturer for extension into manholes before releasing tension.
- The installed FIPP shall form a waterproof seal with the manhole wall. If pipe fails to seal properly, a material compatible with the pipe and manhole shall be used to provide a watertight seal.
- Prior to the installation of FIPP, the Engineer will review the pre-inspection videotapes and logs for each line to determine which services shall be externally reconnected. Service connections that may be a source of I/I or root propagation shall be externally replaced as directed by the Engineer. Such connections shall include but not be limited to a cracked or collapsed connection, missing pipe segments around the connection, presence of roots, or protruding or receding connections.

8.3.2 Point Repair. Point repairs shall be accomplished in accordance with other paragraphs of this specification. The Engineer may delete segments between two consecutive manholes that require more than 4 point repairs or external connections to rehabilitate. At the discretion of the Engineer, these segments may be replaced by conventional excavation. When performing an external connection, the Contractor may at his option perform a point repair prior to lining the pipe or to anchor a saddle to the liner after installation. Groups of services replaced within a 13-foot span are accessed with one point repair using whichever method is used to make the connections.

8.3.3 FIPP Material Testing. Following the installation for each minimum design thickness, the Contractor shall obtain 1 each sample from the formed-in-place pipe as follows:

- Sample Locations. Sample locations shall be determined by the Engineer. When necessary, a point repair shall be done in order to obtain the sample, the cost of which shall be paid for at the unit price bid per each point repair. The Contractor shall cut each sample to a minimum of 3 feet in length, and ship the samples to a laboratory designated by the Engineer for testing as described herein. The results of these tests shall be forwarded to the Engineer directly from the approved laboratory for review.
- Specimens. From each sample, 5 specimens shall be prepared to determine flexural

bending properties, namely the initial flexural modulus and flexural strength and thicknesses. The results of each test shall be used to determine average values. Tests and measurements shall be in accordance with ASTM Test Method D 790 and the calculated average values shall meet the minimum material properties and thickness(es) established in these specifications.

- Cost. The cost of each test, when the material passes, shall be borne by the City. When average test results do not pass, the Contractor shall be responsible for the cost.
- Acceptance - When the average test meets the requirements of these specifications, the testing shall be considered accepted.

8.3.4 Acceptance of the FIPP. Final acceptance of the FIPP shall be based on, but not limited to, review of closed circuit television inspection, the required material testing, and conformance with all provisions of these specifications as determined by the Engineer. Additionally, no groundwater shall be observed and all service entrances shall be accounted for and unobstructed. The installed formed-in-place pipe shall be continuous over the entire length of a run between manholes and be smooth and free from substantial wrinkles, as well as flat spots, reverse curvature, defects, improper house connection cut-outs and installation over debris. Should any of these defects occur, the line shall be excavated, repaired, and/or replaced, and complete restoration shall be made to the satisfaction of the Engineer at no additional cost to the City.

8.4 METHOD OF MEASUREMENT. Payment for "Formed-In-Place Pipe" shall be made at the unit price bid per linear foot of pipe for each size. External connections (reinstatements) of services shall be considered incidental to the lining process and the cost for such shall be included in this bid item. The price established shall be full compensation for all labor and materials including FIPP material, installation, external connection of services, equipment, tools, testing, and incidentals necessary to complete this item of work. All lengths shall be measured horizontally from centerline to centerline of manholes.

8.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

FORMED-IN-PLACE PIPE (SIZE)	LF
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Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

9.0 SEWER FLOW CONTROL

9.1 DESCRIPTION. This section covers necessary sewer flow control to the extent required for each operation, as specified and directed by the Engineer.

9.1.1 Sewer Flow Control for Television Inspection and Smoke Testing. When depth of flow at the upstream manhole of the section being worked is above the allowable for television inspection, the flow shall be reduced to the level shown below by operation of pumps, plugging or blocking of the flow, or by pumping and bypassing of the flow as specified. Depth of flow shall not exceed 25% of the respective pipe sizes as measured in the manhole.

9.1.2 Sewer Flow Control for All Other Operations. The line shall be completely blocked off and plugged and all flows shall be by-passed to the extent necessary or as required by the Engineer.

When pumping and bypassing is required the Contractor shall supply the pumps, conduits, and other equipment to divert the flow of sewage around the manhole section in which work is to be performed. The bypass system shall be of sufficient capacity to handle existing flow plus additional flow that may occur during a rainstorm. The Contractor will be responsible for furnishing the necessary labor and supervision to set up and operate the pumping and bypassing system. If pumping is required on a 24-hour basis, engines shall be equipped in a manner to keep noise to a minimum. Precautions must be taken to insure that sewer flow control operations do not cause flooding or damage to public or private property being served by the sewers involved. The Contractor shall be liable for damages resulting from sewer surcharge.

9.2 METHOD OF MEASUREMENT. Payment for "Sewer Flow Control" shall be made at the unit price bid per lump sum. The price established shall include furnishing and operation of pumping and by-passing, labor, tools, and incidentals necessary to complete this item of work. Plugging or blocking of the sewer flow shall be considered incidental to the work and shall not be considered for payment.

9.3 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SEWER FLOW CONTROL LS

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

10.0 CLEANING SEWER LINE

10.1 DESCRIPTION. This section covers cleaning of existing sewer lines. The designated sewer manhole sections and the manholes themselves shall be cleaned using mechanical, hydraulically propelled and/or high velocity sewer cleaning equipment. Selection of the equipment shall be based on the condition of the sewer mains at the time the work commences. The equipment shall be capable of removing dirt, roots, sand, rocks, grease, and other materials from the sewer lines.

10.2 EQUIPMENT

10.2.1 Approval of Cleaning Equipment and Procedure. The Engineer shall approve the cleaning system and plan for each manhole section. The Contractor shall demonstrate the performance of the proposed cleaning equipment for use on the project. No work shall begin until the Engineer gives such time approval.

10.2.2 Mechanically Powered Cleaning Equipment.. Bucket machines shall be in pairs with sufficient power to perform the work in an efficient manner. Machines shall be belt operated or have an overload device. Machines with direct drive that could cause damage to the pipe will not be allowed. A power rodding machine shall be either a sectional or continuous rod type capable of holding a minimum of 300 feet of rod. The rod shall be heat-treated (tempered) steel. To ensure safe operation, the machine shall be fully enclosed and have an automatic safety clutch or relief valve.

10.2.3 Hydraulically Propelled Cleaning Equipment. Hydraulically propelled devices that require a head of water to operate shall utilize a collapsible dam to obtain the head. The dam shall be designed to easily collapse in the event of a sudden surcharge of the line to prevent damage to the

sewer, property, etc. Sewer cleaning balls are acceptable for use only in sanitary sewers having a diameter of 18-inches or greater. The movable dam shall be of equal diameter as the pipe being cleaned and shall provide a flexible scraper around the outer periphery to ensure effective operation. Whenever possible, flows present in the sewer lines shall be used to provide necessary fluid for hydraulic cleaning devices.

10.2.4 High Velocity Cleaning Equipment. All high-velocity sewer cleaning equipment shall be constructed for ease and safety of operation. The equipment shall have a selection of 2 or more high-velocity nozzles. Equipment shall also include a high-velocity gun for washing and scouring manhole walls and floor. The gun shall be capable of producing flows from a fine spray to a solid stream. The equipment shall carry its own water tank, auxiliary engines, pumps, and hydraulically driven hose reel. Filler piping on the tank shall have an air cap to prevent backflow and contamination of water supply system.

10.3 CONSTRUCTION METHODS.

10.3.1 Cleaning Precautions. Satisfactory precautions shall be taken to protect the sewer lines from damage that might be caused by the improper use of cleaning equipment. Whenever hydraulically propelled cleaning force or any tools which retard the flow of water in the sewer line are used, precautions shall be taken to ensure that the water pressure created does not cause any damage or flooding to public or private property being served by the manhole section involved. Additionally, the Contractor shall not allow the overflow from sanitary sewers to enter storm sewers. The Contractor, at no additional cost to the City, and to the satisfaction of the Engineer, shall repair any damage inflicted upon the sewer, regardless of the cleaning method used.

10.3.2 Root and Debris Removal. All roots shall be removed. Special attention shall be given during the cleaning operation to assure complete removal of roots from the joints. Procedures may include the use of mechanical equipment such as rodding machines, bucket machines and winches using root cutters and porcupines, and equipment such as high-velocity jet cleaners.

- Chemical root treatment may also be used. When chemicals are used to aid in the removal of roots, the chemical shall be EPA registered and labeled for use in sewer lines and acceptable to all applicable State and City agencies. All materials and mixing/application procedures for chemical root treatment shall be consistent with the latest standards, requirements, and recommendations of the manufacturer of the chemical root treatment material used.
- All sludge, dirt, sand, rocks, grease, and other solid or semi-solid material resulting from the cleaning operation shall be removed at the downstream manhole of the section being cleaned. Passing of debris from manhole to manhole shall not be permitted. When hydraulic cleaning equipment is used, a suitable sand trap, weir, or dam shall be constructed in the downstream manhole in such a manner that the solids shall be trapped.
- All solids or semi-solids resulting from the cleaning operations shall be removed from the site and disposed of at no additional cost to the City. Under no circumstances shall sewage or solids removed therefrom be dumped onto streets or into ditches, catch basins, storm drains, or sanitary sewer manholes.

10.4 TESTING, CLEANING AND FINAL ACCEPTANCE. Acceptance of sewer line cleaning shall be made upon the successful completion of the television inspection and shall be to the satisfaction

of the Engineer. If television inspection shows the cleaning to be unsatisfactory, the Contractor shall be required to reclean and reinspect the sewer line until the cleaning is shown to be satisfactory.

10.5 METHOD OF MEASUREMENT. Payment for "Cleaning Sewer Line" shall be made at the unit price bid per lineal foot of pipe regardless of size. The price established shall be full compensation for furnishing and operation of all equipment, labor, tools, and incidentals necessary to complete this item of work. No deduction shall be made for manholes.

10.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

CLEANING SEWER LINE LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

11.0 SMOKE TESTING

11.1 DESCRIPTION. This section covers testing of sewer lines with smoke where the origin of a connection as an inflow source is unknown. Common uses are to determine storm sewer cross connections, roof leaders, cellar, yard, fountain and area drains, abandoned building sewer and faulty service connections, and point source inflow due to leaks in drainage paths and ponding areas.

11.2 CONSTRUCTION METHODS. Smoke testing shall not be used in sewer lines suspected of having sags or water traps or those that are flowing full. Smoke testing shall not be conducted to locate service connections when the soil surrounding and above the pipe is saturated, frozen or snow covered. Smoke generated from bombs or canisters shall be non-toxic, odorless and non-staining. Air blowers shall have a minimum capacity of 1600 liters/second. Police and fire departments shall be notified daily of the test locations. Also residents shall be informed individually on the day of testing by personnel displaying proper identification. Photographs shall be taken of all leaks discovered during testing, and shall be numbered and direction orientated. They shall be taken close enough to clearly mark the point where the smoke is escaping. The Contractor shall also submit a sketch of each leak describing its extent, the area and type of surface drained by it, the location or address, and the photograph number. The leak shall be marked at the site.

11.3 METHOD OF MEASUREMENT. "Smoke Testing" shall be measured by the lineal foot of sewer line tested. Payment for "Smoke Testing" shall be made at the unit price bid per foot regardless of pipe size. The price established shall include all materials, labor, tools, equipment and incidentals necessary to complete this item of work.

11.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SMOKE TESTING LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

12.0 DYE-WATER TESTING.

12.1 DESCRIPTION. This section covers dye-water testing used for detecting inflow such as storm sewer cross connections and point source inflow leaks in drainage paths or ponding areas, roof leaders, cellar, yard and area drains, fountain drains, abandoned building sewers, and faulty service connections. Dye-water testing shall only be performed as directed by the Engineer where the origin of a connection is questionable.

12.2 CONSTRUCTION METHODS. The equipment needed for dye-water testing shall be limited to that required to carry the water to testing site and to block the sewers before testing. Sand bags or sewer pipe plugs may be used to block the sewer sections. When inflow sources are located on private properties, property owners shall be notified before tests to identify in-flow sources. A field log sheet shall be filled out for each dye-water test whether or not a positive transference is observed. A sketch shall be made. It shall indicate exactly what was flooded and the relationship between that and the sewer system. A photograph shall be made to accompany the sketch. The photograph shall include the set up or the point of ingress. Dye shall be safe to handle, visible in low concentrations, miscible in water, inert to the soils and debris in the sewers, and biodegradable.

12.3 METHOD OF MEASUREMENT. The cost of dye-water testing shall be considered incidental to the process of sewer analysis, smoke testing and similar investigations and no additional compensation shall be made for this work and the cost of same shall be included in the other pay items.

13.0 POINT REPAIR

13.1 DESCRIPTION. This section covers replacement of short segments of sections of the existing pipe as specified or directed by the Engineer. The point repair is made by excavation to repair a line or remove an obstruction such as dropped joints, protruding service connections, or crushed or collapsed pipe, which cannot be removed or repaired by remote devices.

13.2 CONSTRUCTION METHODS. All point repairs require prior approval of the Engineer. Pipe and fittings for point repairs shall be installed and trench excavation and backfill shall be performed according to the provisions of this specification. The length of any point repair shall not exceed 12 feet. Site cleanup and replacement of trees, shrubs, hedges, and sod shall be in accordance with the appropriate sections of the specifications.

13.3 METHOD OF MEASUREMENT. Payment for "Point Repair" shall be made at the unit price bid per each regardless of depth. The price established shall include all material, equipment and labor costs for excavation, pipe, replacement, embedment materials, cleanup, and incidentals necessary to complete a point repair. Repair or replacement of sod, trees, shrubs and hedges shall be paid for as a part of site clearing and restoration. Paving shall be replaced and paid for directly in accordance with the appropriate section. Removal of obstructions by internal means shall be considered incidental to work. Television inspection and cleaning of sanitary sewer in pursuit of repair shall be considered incidental to work.

13.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

POINT REPAIR EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

14.0 DEFLECTION TEST

14.1 DESCRIPTION. This section covers deflection tests intended to be performed on all flexible pipe installations.

14.2 TESTING.

14.2.1 A mandrel (go/no-go) device cylindrical in shape shall be hand-pulled by the Contractor through all sewer lines. Any sections of pipe not passing the mandrel test shall be uncovered and the Contractor, at no additional cost to the City, shall replace the pipe to the satisfaction of the Engineer. The repaired sections shall be re-tested. All tests for pipes 24-inch and larger shall be performed in the presence of the Engineer. The Engineer shall approve the mandrel and the testing procedures. Proving rings furnished by the Contractor shall be used to verify the mandrel diameter. In lieu of mechanical measurement of deflection by a mandrel, manual measurement can be performed using an internal micrometer or telescoping gage accurate to plus or minus (\pm) 0.001-inch. The manual measurement of the vertical internal diameter shall be taken at the centerline of the installed pipe.

14.2.2 The test shall be performed not less than 30 days after backfill has been placed. The maximum allowable deflection shall not exceed 5% of the pipe's base internal diameter (Base ID). Base ID for PVC pipes shall be calculated from measurements taken in accordance with ASTM D2122 and according to procedures outlined in Appendix XI of ASTM D3034. For PE pipes Base ID shall be calculated from measurements taken in accordance with ASTM D2122 and according to procedures recommended by the manufacturer and approved by the Engineer. For other flexible pipes, base ID shall be calculated in accordance with the manufacturer's recommended procedures and approved by the Engineer.

14.3 METHOD OF MEASUREMENT. Payment for "Deflection Test" shall be made at the unit price bid per lump sum for pipes smaller than 24-inches and per lineal foot for pipes 24-inches and larger in diameter. The price established shall be full compensation for all material, labor, tools, equipment and incidentals necessary to complete this item of work.

14.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

DEFLECTION TEST (< 24")	LS
DEFLECTION TEST (24" AND LARGER)	LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

15.0 TELEVISION INSPECTION

15.1 DESCRIPTION. This section covers closed-circuit television (CCTV) inspection of existing sewer lines and rehabilitated and newly constructed sewer lines. The work shall consist of furnishing all labor, materials, accessories, equipment, tools, transportation, services and technical competence for performing all operations required to professionally execute the internal inspection of sewers in strict accordance with these specifications. Information concerning depths of flow, manhole depths, air quality in the sewers, accessibility of manholes, traffic conditions, and other safety considerations are to be the sole responsibility of the Contractor to obtain and to incorporate the necessary provisions into the overall contract price to complete the specified work

under the conditions existing in the sewers to be inspected. The Contractor may be required to submit sample video recordings from recently completed projects demonstrating the picture quality obtained with each available inspection system for pipe diameters 27-inch and larger. All television testing shall be performed in accordance with guidelines published by the National Association of Sewer Service Companies (NASSCO) and as modified or specified in these specifications.

15.2 EQUIPMENT. All television cameras used for inspection shall be color units specifically designed and constructed for the method of inspection performed. Camera(s) may be modified by mounting on conventional or floating skids, or rafts, for use in multiple-diameter, sewer line inspection work.

- Units shall have either automatic or remote focus and iris controls, and the complete system(s) shall be operable in conditions of 100% humidity.
- Lighting shall be suitable to allow a clear picture of the entire periphery of the main sewer pipe. For 27-inch and larger pipe, the camera lens shall have not less than a 65° viewing angle. A radial viewing camera with a 360° vertical rotation and a 270° horizontal rotation, or any combination of the two, may be required to properly evaluate the condition of the main sewer and laterals. Lighting shall operate in a manner that allows the viewed object to be illuminated no matter what the angle of the lens. For a radial viewing camera, the lighting shall be built into the unit so that the lamp(s) remains aligned with the lens. A minimum illumination of 3 lux with a light color in the 2200° to 3200° Kelvin range shall be provided. Auxiliary lighting acceptable to the Engineer shall be provided for large diameter pipe. For diameters of 60-inch and greater, a minimum of 1,000,000 candlepower lighting in the 3200° Kelvin range shall be made available.
- The Contractor shall be responsible for having the necessary camera skids, floats, and rafts available to allow for inspection of lines in a manner acceptable to the City under live flow conditions. In all cases, the complete video system (camera, lens, lighting, cables, monitors and recorders) shall be capable of providing a picture quality acceptable to the Engineer, and if unsatisfactory, equipment shall be removed and no payment shall be made for unsatisfactory inspections.

15.3 CONSTRUCTION METHODS.

15.3.1 General. The Contractor shall use one of the following methods individually or in combination, as approved by the Engineer:

- Conventional color inspection cameras specifically designed for use in sewer line inspection work, mounted on conventional camera skids or tracks.
- Conventional color inspection cameras specifically designed for use in sewer line inspection work, mounted on floating skids or rafts.
- Special industrial grade, color-inspection cameras contained in waterproof housings, and mounted on floating skids or rafts
- Special industrial grade, color-inspection cameras, either hand held or contained in waterproof housings, and carried manually through the sewer during inspection work.

15.3.2 Pre-work Submittals For Inspection Of Large Diameter Pipes. For pipes 27-inches and larger, the Contractor shall submit a listing of actual measured flow depths and times of

measurement at a sufficient number of locations to indicate the flow depths that could be expected during inspection work. A minimum of one (1) flow depth measurement shall be provided for each line section at no additional cost to the City. Additional off-peak flow measurements (i.e., night flow measurements) may be requested by the Engineer at various locations, also at no additional cost to the City.

15.3.3 Pre-work Meeting. A prestart-up meeting shall be scheduled prior to beginning any internal pipe inspection work to review the Contractor's proposed inspection methods for each of the line section groupings. At that time, the Contractor shall have available the necessary flow depth data as well as the overall listing of proposed inspection methods in each area.

15.3.4 Preparation. The main sewer shall be cleaned as directed by the Engineer and in accordance with these specifications of grease, roots and debris that may hinder movement of inspection equipment through the lines. Major line obstructions that require point repairs are excluded.

15.3.5 Flows. The maximum flow depth for remote inspection work in pipes 24-inch and less is 20% of the pipe diameter. For pipes 27-inches and greater, the maximum flow shall be 30% of the pipe diameter. The contractor may be required to perform inspections during off-peak hours (night inspections) when specifically requested by the Engineer to obtain this flow standard. No inspections shall be performed where flow depths exceed fifty (50%) percent of pipe diameter without prior approval of the Engineer. Suspended moisture or fog in pipes shall be cleared with blowers. Filming shall commence only when the ambient temperature above ground is a minimum of 40°F.

15.3.6 Inspection. CCTV inspection shall be done one manhole section at a time and the flow in the section being inspected shall be suitably controlled. The inspection shall proceed from one section to another starting either upstream or downstream and completing in that order for the entire line. When an obstruction prevents the camera from passing through the entire manhole section, the inspection shall be continued from the opposite manhole before proceeding to the next section.

- The camera shall be moved through the line at a moderate rate, stopping when necessary to permit proper documentation of the sewer's condition. The maximum speed of the camera shall not exceed 30 feet per minute.
- The camera shall be moved through the line by conventional means of manual winches, power winches, television cable, and powered rewinds or other devices, which do not obstruct camera view or interfere with proper documentation of the sewer conditions. In instances where manual or remote power winches are used to pull the camera through the sewer constant two-way communication shall be set up between the two manholes of the line being inspected.
- Accurate and continuous footage readings shall be superimposed on the video recording for each line inspected by remote inspection methods. Also shown shall be the date of inspection and a manhole number designation that corresponds to the field logs for each manhole on the line section inspected.
- [When specified, a lateral sewer camera shall be employed to inspect up to 25 feet of the lateral. The lateral camera launcher shall be brought into position by the main sewer

television camera. Lateral sewers entering manholes shall be inspected with a mini push camera. Actual footage inspected shall vary depending on the condition of the pipe. Videotapes of laterals may be in black and white, and shall show a view of the lateral connection by the main sewer camera before showing the internal view of the lateral by the launcher.]

- The Contractor shall provide photographs developed from the television screen of problems revealed by the CCTV camera upon the request of the Engineer, as long as such photographing does not interfere with the Contractor's operations.

15.3.7 Manual (Walk-Through) Inspections. Manual inspections may be required in lines where conditions will allow the Contractor's inspection crew to safely walk through the sewer. In general, lines 60-inch in diameter and larger, and having flow depths of less than 20% of the pipe diameter, shall be manually inspected as directed by the Engineer. Inspection crews shall consist of two or more people. Blowers and exhaust fans shall be available to provide ventilation for the sewer line being inspected.

- Manual pipe inspections, if permitted, shall be conducted in such a manner as to transmit the video signal to an aboveground viewing room to permit the Engineer to watch the inspection work live on a color monitor in the viewing facility. In addition, direct voice communication between the Engineer, the in-pipe inspection personnel, and the recording technician in the aboveground unit shall be maintained at all times during the manual inspection work. Video recording equipment shall also be located above ground in the inspection truck and accurate, continuous footage readings shall be superimposed on the video recording for permanent record.
- During manual inspections, the video camera shall be used to look up sidelines and laterals, whenever practical. Conditions noted in these sidelines and laterals shall be noted on the inspection logs and videotapes for the project. During manual inspections, color photographs shall be obtained as instructed by the Engineer or as deemed necessary by the in-pipe technicians to document line conditions.

15.4 DOCUMENTATION. The results of CCTV inspection shall be thoroughly documented so as to eliminate the need for reinspections and filed and labeled for easy interpretation and understanding.

15.4.1 Television Inspection Logs. Printed location records shall be kept by the Contractor and will clearly show the location in relation to an adjacent manhole of each infiltration point observed during inspection. In addition, other points of significance such as locations of building sewers, unusual conditions, roots, storm sewer connections, broken pipe, presence of scale and corrosion, and other discernible features will be recorded and a copy of such records shall be supplied to the Engineer. The video audio recording and written report of the condition of each lateral, if inspected, shall be included along with an identification number corresponding to main sewer log and approximate locations of any pipe defects. During large-diameter pipe inspections, the Contractor shall document in writing observed conditions and comments given about each sewer line. These field logs shall then be reviewed by the Contractor's technical staff, along with reviewing the associated video record, as a means of ensuring that no defects or entries are omitted or incorrect, and as a means of gaining a second opinion as to the condition of each sewer line. Edited field logs shall then be reprinted or typed for use in the final project reports. Detailed, one-page summaries shall also be prepared for each line section inspected, during the data review, presenting the Engineer's synopsis of the general line condition and the relative severity of

observed defects. These summaries shall also be included in all field report copies immediately before each associated inspection report. Direct submittal of copies of the field technician's field logs, without this secondary review and summary pages, shall not be acceptable.

15.4.2 Reports. Five (5) complete copies of the final project reports shall be submitted to the City within 20 calendar days of completion of all field activities. One of the 5 copies shall contain the original photos. An overall summary narrative shall be provided in the final report describing the overall conditions found in each associated line section grouping and detailed summary tables shall also be compiled showing those lines where major and significant defects were located. Original recordings, along with the required submittals, shall be forwarded to the Engineer upon completion of the inspection and shall become the property of the City.

15.4.3 Video Audio Recordings. A forward introduction sequence stating the time and date, location or segment number, depth, diameter, and pipe material for each length between manholes shall precede the recording of each line segment. The camera shall proceed through the pipe indicating the beginning manhole and destination manhole as it marks the footage continuously. Should there be a need to access the line from the other direction, a new introduction track shall precede the setup, and the footage shall begin at zero.

- The camera shall pause as it approaches a service so that the connection between pipe and service may be evaluated. The lens shall then rotate to display the interior of the service. The service inspection should reveal any roots, cracks, or capped risers. Audio description shall accompany the visual. Operator's comments shall contain verbal verification of footage and condition of each service, and any defects or unusual conditions noted in the main. When television inspection is performed as a part of final examination for acceptance of project, it shall be performed after all the lines have been constructed and within 24 hours of conducting deflection test on a line. It shall be continuous and present each segment in the order laid out in the plans (e.g., Line A: station 0+00 to 4+00, station 4+00 to 8+00, Line B: station 0+00 to 3+00, etc.).
- All recordings shall be in a commercially-common, standard format or a format specified by the Engineer. Each recording shall be professionally labeled showing the Owner's name, project number, project location, the date(s), etc., lines recorded on the tape, and name of the Contractor. If the quality of the recordings is not satisfactory to the Engineer, the lines shall be re-recorded at the Contractor's expense.

15.4.4 Photographs. All photographs taken during manual, walk-through inspections shall be properly mounted and labeled on 8-1/2 x 11-inch paper for inclusion in the final project reports. The photo pages shall be presented immediately following the inspection report for the line section in which they were taken. Photographs taken from the monitor for remote television inspections shall also be presented in the same manner as described above.

15.4.5 Report Formats. The reports, documents, photos, notes and logs, from whatever source, shall be assembled in multiple 3-ring binders of not more than 2-inches in width, copied in Adobe pdf digital form, and archived on CDs, flash drives or other digital devices acceptable to the City.

15.5 METHOD OF MEASUREMENT. Payment shall be made for pre-construction inspection, when required for construction, and post construction inspection only. Unless separately specified, all other recording and/or photographs requested by the Engineer shall be considered incidental to the project and the cost included in the price for other items. "Television Inspection" shall be measured along the stations, through manholes, junction boxes and other

small structures. Payment for "Television Inspection (CCTV)", which may include manual inspections, shall be made at the unit price bid per lineal foot of pipe regardless of size. The price established shall be full compensation for all equipment, labor, materials, mobilization, demobilization, reverse setups, recordings, reports, photographs, and incidentals necessary to complete these items of work.

15.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

TELEVISION INSPECTION (CCTV) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

16.0 SEWER PIPE LEAKAGE TESTING

16.1 DESCRIPTION. After backfilling has been completed, the Contractor shall conduct infiltration, exfiltration or air tests as directed by the Engineer and submit the results of all testing to the Engineer. All tests shall be performed in the presence of the Engineer for pipes 24-inches and larger. Immediately prior to conducting a test, the ground water level shall be determined by boring a vertical hole adjacent to the pipe and measuring the distance to the water level, or by the use of a 1-inch diameter pipe installed horizontally through the upstream manhole wall with a clear plastic tube connected to the pipe and extending vertically.

16.2 INFILTRATION TEST. Where sewers are laid under the groundwater, infiltration testing shall be conducted. If at any time the infiltration between two adjacent manholes is observed and measured to exceed 10 gallons per inch of nominal pipe diameter per mile of sewer per day. The Contractor shall locate the leakage and shall make such repairs as are necessary to reduce the infiltration. The infiltration shall be measured under the direction of the Engineer by use of a weir or other suitable flow rate-measuring device furnished and installed by the Contractor.

16.3 EXFILTRATION TEST. Where sewers are laid above the groundwater table, exfiltration testing shall be conducted. Exfiltration tests shall be conducted by blocking off the other openings in the upper manhole and plugging the line where it enters the lower manhole of the reach to be tested, filling the line and the manhole with water at least 5 feet higher than the top of the pipe or 5 feet higher than the ground water elevation whichever is higher, and measuring the water required to keep the water level in the manhole at a constant elevation. The test section shall be filled not less than 12 hours prior to testing. The total exfiltration shall not exceed 10 gallons per inch of nominal pipe diameter per mile (idm) of pipe per day for each reach tested. For purposes of determining the maximum allowable leakage, manholes shall be considered as sections of pipe having an idm equal to the diameter times depth of the manhole. The exfiltration test shall be maintained on each reach for at least 2 hours or longer if, in the opinion of the Engineer, this is necessary to locate all leaks. The Contractor shall provide all necessary piping between the reach to be tested and the source of water supply, together with equipment and materials required for the tests. The methods used and the time of conducting the exfiltration tests shall be subject to the approval of the Engineer. If the leakage in any reach exceeds the allowable maximum, the Contractor shall locate the leakage and shall make such repairs as are necessary for the pipe to pass testing. The pipe reach shall be retested after the leaks are repaired.

16.4 AIR TEST. Air tests shall be conducted on each manhole-to-manhole section of sewer. The air test shall be performed in accordance with the following specifications.

16.4.1 Equipment. Cherne Air-Loc Equipment as manufactured by Cherne Industrial of Hopkins, Minnesota or approved equal. Equipment used shall meet the following requirements:

Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected. Pneumatic plugs shall resist internal test pressure without requiring external bracing or blocking. All air used shall pass through a single control panel. Three (3) individual hoses shall be used for the following connections: From the control panel to pneumatic plugs for inflation; from the control panel to sealed line for introducing the low pressure air; and from sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

16.4.2 Procedures. All pneumatic plugs shall be seal-tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psi. The sealed pipe shall be pressurized to 5 psi gauge. If a ground water level over the top of the pipe is present, the pressure in psig shall be increased by the height of ground water level above top of pipe at upstream manhole (divided by 2.3). The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe. After a manhole reach of pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedures, the plugs shall be placed in the line at each manhole and inflated to 25 psi gauge. Low-pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psi gauge. At least 2 minutes shall be allowed for the air pressure to stabilize. After the stabilization period, the air hose from the control panel to the air supply shall be disconnected. The portion of the line being tested shall be termed "acceptable" if the time required in minutes for the pressure to decrease from 3-1/2 ps to 2-1/2 psi gauge is not less than that shown in the following "Air Test Requirements" table.

Pipe Nominal Size (Inches)	Minimum Test Time (min:sec)	Length for Minimum Time
6	2:50	751
8	3:47	564
10	4:43	450
12	5:40	376
18	8:30	250
21	9:55	215
24	11:20	188
27	12:45	167
30	14:10	150
36	17:00	125
42	19:50	107
48	22:40	94
54	25:30	83
60	28:20	75
66	31:10	68
72	34:00	63
84	39:40	54
90	42:35	51
96	45:20	47

If the air leakage in any reach exceeds the allowable, it shall be re-tested after the leaks are repaired.

16.3 METHOD OF MEASUREMENT. Payment for "Sewer Leakage Test" shall be made at the unit price bid per lump sum for pipes smaller than 24-inch and per lineal foot for pipes 24-inches and larger in diameter. The price established shall be full compensation for all material, labor, tools, equipment and incidentals necessary to complete this item of work.

16.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SEWER LEAKAGE TEST (SIZE)	LS	[For less than 24"]
SEWER LEAKAGE TEST (SIZE)	LF	[For 24" and larger]

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

17.0 SANITARY SEWER MANHOLES

17.1 DESCRIPTION. This section covers construction of sanitary sewer manholes to 6 feet deep. Manholes may be constructed as Precast Reinforced Concrete [Para 17.2] or Cast-In-Place Non-Reinforced Concrete [Para 17.3].

17.2 PRECAST REINFORCED CONCRETE MANHOLES. This paragraph covers materials and construction of precast reinforced concrete manhole base sections, riser sections (walls) and appurtenances in accordance with ASTM C478 Standard Specification for "Precast Reinforced Concrete Manhole Sections" and as modified herein.

17.2.1 Submittals. When requested by the Engineer, the Contractor shall submit the following, but not limited to, for review and approval.

- Concrete cylinder compressive test results as per ASTM C478.
- Amount and detail layout of steel reinforcement as per ASTM C478.
- Type "D" Certification for the specified protective coating.
- Daily log of applied protective coating.
- Affidavit of compliance with these specifications.

17.2.2 Types. Components of precast reinforced concrete manholes include:

- Cylindrical type Precast Risers and Grade Rings
- Precast tops shall be Concentric cone, Eccentric cone
- Precast Base riser section and separate base slab with Mastic sealer
- Base riser section with integral floor and preformed socket to accept a rubber ring.

17.2.3 Sizes. The standard internal diameter of a manhole shall be 4 feet. Non-standard internal diameters of 5, 6, and 7 feet may be constructed when specified or called for on the plans. The manholes shall be constructed pursuant to the appropriate "Standard Details for Precast Reinforced Concrete Manholes", and/or as specified in ASTM C478. The minimum wall thickness shall be as specified in the following table or not less than 1/12 of the internal diameter of the largest cone or riser section or 5-inches, whichever is greater.

Manhole Diameter and Wall Thickness	
Manhole Internal Diameter (feet)	Minimum Wall Thickness (inches)
4	5
5	5
6	6
7	7
8	8

17.2.4 Materials and Design. All materials for construction of manholes shall be in accordance with Section 6 of ASTM C478. Design including concrete properties, reinforcement type and grade, joints, manufacturing and physical requirements shall be in accordance with Section 7 to 10 of ASTM C478.

- Base Slabs. Base slabs or floors shall have a minimum riser thickness of 6-inches for diameters up to and including 48-inches and a thickness of 8-inches for larger diameters.
- Manhole Steps and Ladders - Steps and ladders shall not be constructed unless otherwise directed by the Engineer. If called for, they shall conform to Section 13 of ASTM C478.
- Protective Coating. All inside surfaces (walls, bottom, and etc.) of pre-cast concrete manholes shall be shop-coated with a total dry film thickness of not less than 8 mils of TNEMEC Series 69 Hi-Build Epoxoline II, or approved equal. The material manufacturer shall furnish an affidavit attesting to the successful use of their material as a lining for applications where sewage conditions are recognized as corrosive or otherwise detrimental to concrete. Coating materials shall be stored, mixed, applied and cured in accordance with guidelines set by the manufacturer.
- Field Testing. When directed by the Engineer, a set of three cylinders, three (3") inches in diameter, shall be cut from randomly selected manholes. Testing shall be performed to verify compliance with the requirements of these specifications. Basis of acceptance for testing shall be in accordance with the appropriate ASTM requirements. Acceptance. Acceptance of manhole structure shall be based on the conformance and performance of materials required in ASTM C478 and the Engineer's inspection of the installed product. The assessment shall include, but not be limited to, the Engineer's random plant inspections during production, the quantity and the placement of reinforcement, surface fractures and roughness, cut cylinders from the manhole, and the test results of compressive strength performed on cores and cured cylinders in accordance with Section 7 of ASTM C497.

17.3 CAST-IN-PLACE NON-REINFORCED CONCRETE MANHOLES. This paragraph covers construction of cast-in-place non-reinforced manholes consisting of plain concrete walls with brick masonry or precast grade ring at the surface and rings and covers (castings) to be constructed in accordance with the dimensions and requirements of the standard details.

17.3.1 Types and Sizes. Manholes may be Concentric Manholes, Eccentric Manholes, or Offset Manholes. The standard manhole size shall be 4 feet internal diameter. Non-standard sizes may

be constructed when called for on the plans or specified. The wall thickness shall be a minimum of 8-inches. The manholes shall be constructed pursuant to the appropriate "Standard Details for Cast-In-Place Non-Reinforced Concrete Manholes".

17.3.2 Materials. All materials for the construction of cast-in-place manholes shall be in accordance with the Material Specifications.

17.3.3 Protective Coating. Protective coating shall not be required unless otherwise called for on the plans or as directed by the Engineer.

17.3.4 Acceptance. Ready-mix concrete may be accepted on the basis of Type "E" Certification, provided that all applicable requirements are met, and that visual inspection at destination shows the workmanship and condition of the material to be satisfactory.

17.4 CONSTRUCTION METHODS

17.4.1 Manhole Invert and Bench. All loose materials shall be removed prior to shaping the invert. The invert shall be smooth, U-shaped, have a minimum depth of 1/2 pipe diameter and be channeled across the floor of the manhole using the materials specified herein to obtain the proper form and shape. The bench shall also be formed and built up with concrete approved by the Engineer. Additionally, all work shall comply with the appropriate "Standard Details for Precast Manhole Base Sections" and the "Standard Details for Cast-In-Place Non-Reinforced Concrete Manhole Base Section". For precast manholes, inverts and benches shall be formed and poured in place after manhole base and pipe sections are in place. Materials used for invert or benches shall not be allowed to enter the sewer line. Finished benches shall be smooth and free of any defects that could cause the accumulation of debris.

17.4.2 Manhole Ring and Cover. Cast iron rings, tops, covers, gratings and all cast iron fittings shall be sound, true to form and thickness and neatly finished and shall fit together in a satisfactory manner. Castings shall be clean, uniform and whole, and without blow or sand holes, dross, hardspots, shrinkage, distortion or any other surface defects which would impair serviceability. Casting surfaces shall be smooth and well cleaned by shot blasting or other approved cleaning method. Plugging or filling of holes or other defects shall not be permitted. Parting fins and pouring gates shall be removed. Sharp edges resulting from fabrication shall be dulled by any acceptable method to ensure safety in handling. Casting shall conform to the requirements of the Standard Specifications for Grey Iron Fittings ASTM A48, Class "30B" for rings and "35B" for covers and the appropriate "Standard Details for Manhole Ring and Cover". All rings and covers shall be accurately and carefully placed. All rings shall be bedded in a substantial layer of mortar, or a flexible ring seal, shall have a full bearing, and shall be set to the exact grade. Unless otherwise shown, place the ring so that the top of covers shall be flush with, or slightly above, the surrounding surface. When each cover is placed in any position on the ring, the side play shall not exceed 1/8-inch in any direction. Wording and markings on covers shall be in accordance with the Standard Details. Rings may be manufactured in accordance with the "Standard Detail for Reversible Manhole Ring". Manhole covers may be manufactured in accordance with the appropriate "Standard Detail for Vented or Non-Vented Manhole Cover". Unless otherwise specified or directed by the Engineer, non-vented manhole covers shall not be used in the streets. Coatings. When called for on the plans or specified, the underside of all manhole covers shall be given 1 coat of asphalt varnish after visual inspection and approval on the job site.

17.4.3 Foundation. Manholes shall be constructed in a dry excavation. A crushed rock foundation mat shall be constructed under the manhole. The mat shall be a minimum of 6-inches thick.

Placement of material, material properties and backfilling shall comply with other pertinent paragraphs of these specifications.

17.4.4 Manhole to Pipe Connection at Inverts. Manhole to pipe connections shall be made pursuant to manufacturer's recommendations and "Standard Details for Concrete Manhole Pipe Connection". In addition, flexible gasket pipe seals shall be required where each pipe enters the wall of manholes. Where possible, the opening for each connecting sewer pipe shall be circular and match the diameter of the pipe. For manholes built over existing lines or for special conditions, horseshoe-shaped openings shall be accepted. Flexible gaskets shall be A-Lok, or an approved equal. The Engineer prior to construction shall approve the method and materials used for grouting any remaining annular space. Flexible pipe seals may be accepted on the basis of Type "D" Certification and a sample, provided that all applicable requirements are met, and that visual inspection shows the workmanship and condition of the material to be satisfactory. All material furnished under certification shall be tagged, stenciled, stamped or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

17.4.5 Above Invert Manhole to Pipe Connection. Above invert manhole to pipe connection shall be constructed in accordance with the "Standard Detail for Above Invert Manhole to Pipe Connection".

17.4.6 Finishing Manhole to Grade. The manhole ring and cover shall be adjusted to grade with concrete grade rings or course(s) of brick masonry. All brick masonry shall meet the requirements of the Material Specifications. Mortar shall be Class D, to which has been added an approved admixture unless otherwise shown on the plans or provided in the special provisions. All brick shall be laid in a full bed of mortar and all joints shall be completely filled with mortar. The joints on the inside face or exposed face of the masonry shall be rubbed full and cut as the brickwork is built up. The masonry shall be built up in level courses, true to line, grade and dimension. Bats shall be used only when necessary to close joints. All brick shall be thoroughly wet down immediately before being placed unless otherwise permitted by the Engineer. All work shall be completed and finished in a careful, workmanlike manner. Old brick masonry shall be thoroughly cleaned and wetted before joining new masonry thereto. Where a mortar coating is required it shall have the minimum thickness shown on the plans, shall be troweled and re-troweled until a uniform, smooth and impervious surface is obtained. All pipes that extend through masonry walls shall be tightly sealed in the wall with mortar throughout the circumference of the pipe. The mortar shall be pressed in and troweled off flush with the face of the wall.

17.4.7 Manhole Inserts. When called for on the plans or specified, manhole inserts shall be installed at locations shown on the Plans or as directed by the Engineer. It shall consist of a new disk, gasket and relief valves etc., meeting the requirements of these specifications, and shall be manufactured by Southwestern Packing and Seals or approved equal. The watertight inserts shall fit the walls and rings. Damaged or missing inserts identified prior to the final inspection shall be replaced at no cost to the City.

17.4.8 Outside Waterproofing. When called for on the plans or specified, waterproofing shall be required on the outside of manholes. The waterproofing material shall be TNEMEC Series 66 Hi-Build Epoxoline or approved equal. The coating shall have a minimum dry thickness of 4 mils. Coatings shall be environmentally non-hazardous. Spray applications shall be shop applied, and field applications are limited to brush and roller. Acceptance of material used for waterproofing shall be on the basis of Type "D" Certification, provided that all applicable requirements are met.

17.4.9 Extra Depth Manhole Wall. Where required to construct manholes beyond a depth of 6 feet, manhole walls shall be constructed to the depth called for on the plans or as directed by the Engineer. The construction requirements for Extra Depth Manhole Wall are the same as for "Sanitary Sewer Manhole".

17.4.10 Manhole Inspection and Acceptance. After manhole construction has been completed, the manhole shall be visually inspected by the Engineer for acceptability. Visual inspection shall be done to check for leaks, thin spots, honey combs, voids, pinholes and conformance with these specifications. Manhole testing shall be accomplished in accordance with the pertinent section.

17.5 METHOD OF MEASUREMENT. Payment for "Sanitary Sewer Manhole" shall be made at the unit price bid per each size for a depth up to 6 feet. The price established shall be full compensation for excavation, backfill, crushed rock foundation, inverts and benches, walls and cones, manhole inserts when specified, ring and cover, protective coating, outside waterproofing when specified, removal of existing manhole when necessary or specified or called for on the plans, brick masonry or precast grade ring and all labor, materials, tools, equipment and incidentals necessary to complete this item of work. Payment for "Extra Depth Manhole Wall" shall be made at the unit price bid per vertical foot for each size [greater than 6 feet in depth]. The price established shall be full compensation for excavation, backfill, protective coating, outside waterproofing when specified, removal of existing manhole, brick masonry, and all labor, materials, tools, equipment and incidentals necessary to complete this item of work. The extra depth shall be measured from the invert to 6 feet below top of cover.

17.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SANITARY SEWER MANHOLE (SIZE)(0'-6')	EA
EXTRA DEPTH MANHOLE WALL	VF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

18.0 MANHOLE TESTING

18.1 DESCRIPTION. This section covers testing of manholes when called for on the plans or specified. Manholes shall be tested, before acceptance, by either performing exfiltration or vacuum test. The Engineer shall determine which test shall be performed.

18.2 TESTING

18.2.1 Exfiltration Test. All incoming and outgoing lines (including services) shall be plugged and the manhole filled with water up to the bottom of the manhole ring. If the water loss exceeds the maximum allowable as shown, the manhole shall be considered to have failed the test. The Contractor shall drain, perform the necessary repairs as directed by the Engineer, and then retest the manhole until it passes, all at no additional cost to the City. The allowable lost for manholes up to 8 feet deep is 1-inch over 5 minutes. For manholes greater than 8 feet deep, the allowable water loss shall be 1/8-inch per vertical foot of depth over 5 minutes.

18.2.2 Vacuum Testing. All incoming and outgoing sewer and service lines shall be plugged, the plugs restrained and the vacuum tester head placed on the manhole ring and sealed. A vacuum of 10" Hg shall then be drawn on the manhole and the time measured for the vacuum to drop to 9"

Hg. The time measured shall be not less than 60 seconds.

18.3 METHOD OF MEASUREMENT. Payment for "Manhole Testing" shall be made at the unit price as bid. The price established shall be full compensation for all material, labor, tools, equipment, and incidentals necessary to complete this item of work.

18.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE TESTING	LS
or	
MANHOLE TESTING	EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

19.0 SANITARY SEWER MANHOLE REHABILITATION

19.1 DESCRIPTION. This section covers rehabilitation of existing manholes. This section is to provide for all aspects of manhole rehabilitation and waterproofing using various procedures either singularly or in combination. Sewer manhole rehabilitation shall include the following work:

- Plugging, patching, and waterproofing of the manhole structure, wall and base
- Plugging, patching and waterproofing chimney, corbel/cone,
- Coatings and sealants to improve surface condition, eliminate infiltration.
- Cleaning, lining or coating of manholes.
- Reconstruction of benches and inverts
- Repair or rebuilding of the manhole chimney and corbel
- Removal of steps or ladder
- Reinstallation or replacement of manhole rings and covers
- Reinstallation of manhole rings for grade adjustment, ring alignment, or inflow elimination.
- Elimination of infiltration/inflow under manhole rings.
- Elimination of inflow through and around manhole covers.

19.2 CONSTRUCTION METHODS

19.2.2 Cleaning Manholes. Prior to any rehabilitation work on manholes, all concrete and masonry surfaces shall be cleaned to the satisfaction of the Engineer. Grease, crud, laitance, loose bricks, mortar, unsound concrete, and other materials shall be completely removed. Water blasting with a minimum of 5,000 psi pressure at the nozzles shall be the primary method of cleaning, however, other methods such as wet or dry sandblasting, acid wash, concrete cleaners, degreasers or mechanical means may be required to properly clean the surface. Surfaces on which these other methods are used shall be thoroughly rinsed, scrubbed, and neutralized to remove cleaning agents and their reactant products. All existing steps and ladders shall be cut and disposed of properly.

19.2.3 Manhole Waterproofing. Waterproofing of manholes shall be accomplished in accordance with other paragraphs of these specifications.

19.2.4 Patching. Work includes patching, reworking, and reforming of invert and bench. Dry voids, cracks, and spalls shall be patched in concrete manholes. Brick manholes shall be re-

pointed and filled.

- Patching material shall be formulated for use in high sulfide environments. Patching material shall be a premixed non-shrink cement-based patching material consisting of hydraulic cement, graded silica aggregates, special plasticizing and accelerating agents, which has been formulated for vertical or overhead use. It shall not contain chlorides, gypsums, plasters, iron particles, aluminum powder, or gas-forming agents or promote the corrosion of steel with which it may come into contact. Set time shall be less than 30 minutes [ASTM C191] with a maximum volume change of 0.02% percent [ASTM C596] and designed to resist freeze-thaw environments. One-hour compressive strength shall be a minimum of 200 psi [ASTM C109] and the ultimate compressive strengths shall be a minimum of 5000 psi [ASTM C109]. Bond strength shall be a minimum of 145 psi [ASTM C321]. If patching material is used in combination with a liner material, the products shall be deemed compatible as determined by the manufacturer. Use Strong-Seal, Octocrete or equal items.
- Loose material shall be removed from the area to be patched or pointed exposing a sound subbase. Holes or voids around steps, joints or pipes, spalled areas and cavities caused by missing or broken brick shall be patched and missing mortar repointed using a non-shrink patching mortar. Cracks not subject to movement and greater than 1/16-inch in width shall be routed out to a minimum width and depth of 1/2-inch and patched with non-shrink patching mortar. Epoxy grouts may be used for filling cracks and voids less than 2-inches in any dimension when preparing surface for application of an epoxy resin lining. The epoxy grout shall be Raven 810 High Build Epoxy Coating or approved equal.

19.2.5 Invert and Bench Construction. Invert and bench reconstruction shall be accomplished per other relevant paragraphs of these specifications.

19.2.6 Raising Manhole. Raising manhole shall be accomplished per other paragraphs of these specifications.

19.2.7 Lowering Manhole. See other relevant paragraphs of these specifications.

19.2.8 Resetting Existing Manhole Ring and Cover. See other relevant paragraphs of these specifications.

19.2.9 Setting New Manhole Ring and Cover. See other relevant paragraphs of these specifications.

19.2.10 Rehabilitation Methods. Manholes may be rehabilitated using one of the following methods as called for on the plans or as directed by the Engineer. Liner shall not be applied until all other repairs have been completed. Methods include

- Cast-In-Place Concrete Manhole Liner
- Cementitious Manhole Liner (Spray Applied)
- Cured-In-Place Manhole Liner
- Composite Manhole Liner (Grouted)
- Elastomeric Manhole Coatings. [Note: This rehabilitation method may be used only on manholes that do not have exposed rebar or bricks missing.]

19.2.11 Service Connections. All service connections shall be reinstated.

19.2.12 Manhole Testing. When called for on the plans or specified, manhole testing shall be accomplished in accordance with other relevant paragraphs of these specifications.

19.4 METHOD OF MEASUREMENT. Payment for "Sanitary Sewer Manhole Rehabilitation" shall be made at the unit price bid per vertical foot for each internal diameter. The price established shall be full compensation for all materials and labor required to clean, patch, line, tools, equipment and incidentals necessary to complete this item of work. Payment for this item shall not be made until all rehabilitation on the manhole has been completed. Measurement shall be made from the bottom of invert to the finished grade.

19.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

SANITARY SEWER MANHOLE REHABILITATION VF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

20.0 MANHOLE WATERPROOFING

20.1 DESCRIPTION. This section covers the requirements for the elimination of infiltration/inflow into manholes that are otherwise structurally sound. The waterproofing of the manhole shall include base, walls, corbel/cone, and chimney of brick, block or pre-cast manholes.

20.2 MATERIALS. The materials used shall be designed, manufactured, and intended for sewer manhole rehabilitation and the specific application in which they are used. The materials shall have a proven history of performance in sewer manhole rehabilitation. The materials shall be delivered to the job site in original unopened packages and clearly labeled with the manufacturer's identification and printed instructions. All materials shall be stored and handled in accordance with recommendations of the manufacturer.

20.2.1 Manhole Waterproofing Materials. After cleaning and preparing surface and when necessary, prior to the application of coatings and linings, active leaks shall either be stopped by application of the materials specified herein or an approved equal. When applying a liner or coating, plugging or channeling infiltration through "bleed" pipes installed at the bottom of the manhole may also be done. Manhole structure waterproofing includes the waterproofing of the manhole base, walls, corbel/cone and chimney. Waterproofing shall be done during high groundwater conditions, unless done in conjunction with application of a liner or coating installed in accordance with other paragraphs of these specifications. The following types of materials are authorized and may be employed as further specified.

20.2.2 Cementitious Grout Materials. A premixed fast-setting, volume-stable waterproof cement plug consisting of hydraulic cement, graded silica aggregates, special plasticizing and accelerated agents not containing chlorides, gas-forming agents, or promote the corrosion of steel it may come in contact with, may be used. Set time shall be approximately 1 minute. Ten (10) minute compressive strength shall be approximately 500 psi. The following materials have been approved for use in accordance with the manufacturer's recommendations: Strong Seal Grout 250, Emaco 503 Hydraulic Cement Standard, Cement's Stop Leak, or equal.

20.2.3 Chemical Grout Materials. All chemical grout or sealant shall comply with EPA

requirements for performance attributes for a sewer sealant. While being injected, the chemical sealant must be able to react/perform in the presence of water (groundwater); the cured material must withstand submergence in water without degradation; the resultant sealant (grout) formation must prevent the passage of water (infiltration) through the sewer joint; the sealant material, after curing, must be flexible as opposed to brittle; in place, the sealant formation should be able to withstand freeze/thaw and wet/dry cycles without adversely affecting the seal; the cured sealant shall be chemically stable and resistant to the mild concentrations of acids, alkalis, and organics found in normal sewage; packaging of component materials must be compatible with field storage and handling requirements. Packaging must provide for worker safety and minimize spillage during handling; Mixing of the component materials must be compatible with field operations and not require precise measurements of the ingredients by field personnel; Cleanup must be done without inordinate use of flammable or hazardous chemicals; residual sealing materials must be easily removable from the sewer line to prevent reduction or blockage of the sewage flow.

- Acrylamide and Acrylic Base Gels - Acrylamide and Acrylic Base Gels shall meet the following requirements: A minimum of 10% percent acrylamide or acrylic base material by volume in the total sealant mixes. A higher concentration (%) of acrylic base material may be used to increase strength or offset dilution during injection; The ability to tolerate dilution and react in moving water during injection; A viscosity of approximately two (2) centipoise which can be increased with additives; A constant viscosity during the reaction period; A controllable reaction time from ten (10) seconds to one (1) hour for acrylamide base gels and from five (5) seconds to six (6) hours for acrylic base gels; a reaction (curing) which produces a homogeneous, chemically stable, non-biodegradable, flexible gel; he ability to increase mix viscosity, density, and gel strength, by the use of additives.
- Polyacrylamide Base Gel - Polyacrylamide Base Gel shall meet the following requirements. A minimum of 10% percent polyacrylamide base material by volume in the total sealant mix. A higher concentration (%) of polyacrylamide base material may be used to increase strength or offset dilution during injection; The ability to tolerate some dilution and react in moving water during injection; A viscosity of 30 to 35) centipoise at 10% percent solids as applied. The ability to increase mix viscosity, density and gel strength by use of additives; A controllable reaction time from 10 seconds to 5 minutes; A reaction (curing) which produces a homogeneous, chemically stable, non- biodegradable, firm, flexible gel; A resistance to degradation over a pH range of 2 to 10.
- Urethane Base Gel - Urethane Base Gel shall meet the following requirements: One (1) part urethane prepolymer thoroughly mixed with between 5 and 10 parts of water by weight; A liquid prepolymer having a solids content of 75 to 85%, specific gravity of 1.04 (8.65 pounds per gallon), and a flash point of twenty degrees F (20°); A liquid prepolymer having a viscosity of 600 to 1200 centipoise at 70° that can be pumped through 600 feet of 1/2-inch hose at 1000 psi at a flow rate of 1 ounce per second; A cure time that is appropriate for field operations; A reaction (curing) which produces a chemically stable and non-biodegradable, tough, flexible gel; The ability to increase mix viscosity, density, gel strength and resistance to shrinkage by the use of additives to the water. Use Avanti International AV-100, Strata Tech ST 502, 510, or 520 Injection Resin, De Neef Hydroacting Seal Foam, Preco Industries' Preco Plus, or Scotch-Seal Brand Chemical Grout 5600 or 5610.

22.2.4 Cementitious Coating Material. A liquid polymer modified hydraulic waterproof coating, which shall provide a secure mechanical and chemical bond. The material shall be available in contrasting colors. When fully cured, the 2 coat or 3 coat system shall be able to withstand nominal hydrostatic pressures without any visible leaks. Use Tammstech Hey'Di Special System, or approved equal.

20.3 CONSTRUCTION METHODS.

20.3.1 Grout Waterproofing Method. The basic equipment shall consist of pumps, containers, injection packers, hoses, valves, and all necessary equipment and tools required to seal manholes. The chemical injection pumps shall be equipped with pressure meters that will provide for monitoring pressure during the injection of the grout sealants. When necessary, liquid bypass lines equipped with pressure-regulating bypass valves will be incorporated into the pumping system.

- Plugging Procedure. At each point of leakage within the manhole structure a hole shall be carefully drilled from within the manhole and shall extend through the entire manhole wall. In cases where there are multiple leaks around the circumference of the manhole, fewer holes may be drilled, providing all leakage is stopped from these holes. Grout ports or sealant injection devices shall be placed in these previously drilled holes in such a way as to provide a watertight seal between the holes and the injection device. A hose, or hoses, shall be attached to the injection device from an injection pump. Chemical sealing materials as specified shall then be pumped through the hose until material refusal is recorded on the pressure gauge mounted on the pumping unit or a predetermined quantity of sealant has been injected. Care shall be taken during the pumping operation to ensure that excessive pressures do not develop and cause damage to the manhole structure. Upon completion of the injection, the ports shall be removed and the remaining holes filled with mortar and finished flush by trowel with the surface of the manhole wall or other surface. The mortar used shall be a non-shrink patching mortar. Small leaks may be sealed without drilling and with grout delivered directly into the site with a caulking applicator.
- Packing Procedure. Dry twisted jute oakum is soaked in polyurethane resin and then manually packed into cavity at site of active flow. Cementitious grouts may be mixed into a thick slurry and then packed directly into gravity. Both procedures require holding the product in place until material sets and the leak is stopped.

20.3.2 Cementitious Waterproof Coating Method. A waterproof, cementitious coating as specified herein shall be applied to all surfaces, from and including the manhole bench to the bottom of the frame. The material shall be applied to surfaces that are free of cracks or voids wider than 1/16-inch. Coating may be applied over minor leaks and weeping around bricks, but major leaks will need to be plugged with cementitious or chemical grout before coating. A minimum of 2 coats of contrasting colors shall be applied. When completed, the coating shall be free of any cracks or holes. After proper curing of the applied materials, any "bleed" pipes that were used shall be removed, and the holes plugged and coated with the specified materials.

20.4 TESTING AND INSPECTION OF WATER PROOFING. After the specified waterproofing work has been completed, the manholes shall be visually inspected and tested by the Contractor (as required) in the presence of the Engineer and found to be acceptable. Manhole structure waterproofing shall be visually inspected for watertightness against leakage of water into the manhole. All visible leaks and defects observed during inspection shall be repaired.

20.5 METHOD OF MEASUREMENT. Payment for "Manhole Waterproofing" shall be made at the unit price bid per each. The price established shall be full compensation for all materials, tools, labor, equipment and incidentals necessary to complete this item of work.

20.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE WATERPROOFING EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

21.0 MANHOLE JOINT WATERPROOFING

21.1 DESCRIPTION. This section covers waterproofing of joints in pre-cast concrete manholes. The work includes the sealing of barrel joints when general structural sealing is not required.

21.2 CONSTRUCTION METHODS. Chemical grout sealing, cementitious sealing, expanded gasket and elastomeric polyurethane resin-soaked oakum method [using dry twisted jute oakum or resin rod with polyurethane resin (water activated)] may be used in accordance with the installation procedures of the respective manufacturers.

21.4 METHOD OF MEASUREMENT. Payment for "Manhole Joint Waterproofing" shall be made at the unit price bid per each manhole. The price established shall be full compensation for all materials, tools, labor, equipment and incidentals necessary to complete this item of work.

21.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE JOINT WATERPROOFING EA [Manhole]

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

22.0 MANHOLE RING WATERPROOFING

22.1 DESCRIPTION. This section covers manhole ring waterproofing. Manhole ring waterproofing includes the sealing of the ring joint area and the chimney above the cone of the manhole with either a manufactured or applied internal or external flexible seal. The seal shall be designed to prevent leakage of water into the manhole. The seal shall remain flexible, allowing repeated vertical movements of the frame due to frost lift, ground movement, or other causes of up to 2-inches and/or repeated horizontal movement of the frame due to thermal movement of pavement or other causes of up to 1/2-inch.

22.2 CONSTRUCTION METHODS. Manhole ring waterproofing shall be accomplished by installation of a manufactured chimney seal or an applied ring seal.

22.2.1 Manufactured Chimney Seal. This product cannot be used on cones or where chimneys are "out of round" by more than 2-inches. If the flexible portion of the seal is made of a rubber type product, it shall have a minimum thickness of 3/16-inch, a minimum unexpanded width of 8-inches

and be fabricated from a high-grade rubber compound conforming to the applicable requirements of ASTM C923.

- The internal seal shall have a double pleated and the external seal a corrugated, expandable center section. Any extension used in conjunction with the sleeve to increase coverage shall be made of the same material and have the same minimum thickness as the sleeve and be designed to be mechanically attached to the sleeve. The bands used for compressing the sleeve and extension against the manhole shall be fabricated from minimum 16 gauge sheet, if channeled, or 5/16-inch diameter stainless steel conforming to ASTM A240, Type 304, for sheet and ASTM A479, Type 304, for rods. Any screws, bolts or nuts used on these bands shall be stainless steel conforming to ASTM F593 and 594, Type 304. The internal seal or its appurtenances shall not extend into the manhole opening to prevent or unduly restrict manhole entry. If the seal is constructed of another flexible material, it shall have both tensile and tear strength equal to or greater than that of the rubber when tested in accordance with the applicable ASTM procedures.
- The contact surfaces for the sleeve and extensions shall be clean, reasonably smooth and circular, and free of excessive voids. If the masonry surface is rough or irregular and will not provide an effective seal, it shall be smoothed with mortar. A bead of butyl rubber caulk shall be applied to the bottom-sealing surface of the seal or extension to fill minor irregularities in the masonry surface. After the rubber sleeve has been placed in the proper position, the bands are positioned and individually tightened or expanded as required to provide a watertight seal. When an extension is used, its top shall be positioned in the bottom band recess prior to installing the bottom band. The bands are then positioned in the extension and tightened or expanded as required to provide a watertight seal. Installation procedures shall be in accordance with the manufacturer's instructions.

22.2.2 Applied Ring Seal. An applied seal is one that is achieved by applying a product, either between the precast adjusting rings of the chimney and under the ring or to either the inside or outside surface of the chimney and ring to provide a seal that meets the performance criteria contained in this section. If the applied sealing product is a butyl compound, all of the surfaces that are to be sealed shall be clean, dry and dust free.

- For application of flexible ring seal between joints, the waterproofing seal shall be applied only when setting the manhole ring to brick or cast-in-place manholes. For precast manholes, the waterproofing seal shall be applied between all adjustment ring joints including the adjustment ring/cone joint, and to set the manhole ring.
- If the applied seal utilizes the elastomeric polyurethane resin-soaked oakum method, each joint shall consist of 2 concentric rings of 2-inch oakum. The outer ring shall be saturated with the urethane-base foam chemical-sealing material. The inner ring, saturated with water, shall be placed to prevent urethane foam from entering the manhole. The oakum saturated with urethane shall be sprayed with water; when foaming begins, the frame shall be set in place.
- If the applied sealing product is a type of material that is applied to either the inside or outside surfaces of the ring and chimney and/or corbel/cone, the surface against which it is applied shall be clean, and free of rust, dust, oil, loose material and other contaminants. The product shall be applied by trowel, roller, or by spraying to achieve a thickness of not

less than 100 mils. The sealing material shall extend far enough onto the ring to insure bonding and cover enough of the chimney to insure sealing. Application procedures shall be in accordance with the manufacturer's instructions.

22.3 METHOD OF MEASUREMENT. Payment for "Manhole Ring Waterproofing" shall be made at the unit price bid per each manhole. The price established shall be full compensation for all materials, tools, labor, including resetting of existing manhole ring and cover, equipment and incidentals necessary to complete this item of work. When waterproofing manhole ring requires installation of a new manhole ring and cover, a separate payment for the new manhole ring and cover shall be made in accordance with these specifications.

22.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE RING WATERPROOFING

EA [Manhole]

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

23.0 MANHOLE COVER WATERPROOFING

23.1 DESCRIPTION. This section covers the waterproofing of manhole covers. Manhole cover sealing includes either the replacement or sealing of existing manhole covers. All of the methods described herein require the thorough cleaning of the ring surface by wire brushing or grinding. Detailed installation procedures shall be in accordance with the manufacturer's instructions.

23.2 CONSTRUCTION METHODS

23.2.1 Cover Conversion. Reuse the existing cover by making it watertight. This is accomplished by installing a gasket between the cover and the cover-bearing surface of the ring and plugging the vent and pick holes. One of the plugs shall be removable to facilitate removal of the cover. Manhole cover gaskets and plugs shall be molded from a high-quality rubber compound such as Nitrile, EPDM or a blend thereof. The rubber product shall have a minimum tensile strength of 2,000 psi with a hardness durometer of 60. The cover gasket shall be provided with an outside rib and have a minimum thickness of three-thirty seconds (3/32) inch.

23.2.2 Manhole Insert. Use the existing cover in conjunction with a watertight insert that is installed under the cover and prevents entry of water into the manhole. The manhole insert shall be designed to prevent inflow through and around manhole covers and manufactured to fit the manhole ring upon which the manhole cover rests. The manhole insert shall be manufactured from a corrosion-resistant material able to withstand the environment of a sanitary sewer system, road salts, oils and fuel that it may come in contact with. The material shall be freeze-thaw resistant and withstand a temperature range of minus 50°F to 200°F. The manhole insert shall have a minimum thickness of 1/8-inch. The insert shall have an approved system of relieving gas and vacuum pressure and shall be complete with a closed-cell neoprene or polyethylene gasket with adhesive backing installed on the underside of the insert rim by the manufacturer.

23.3 METHOD OF MEASUREMENT. Payment for "Manhole Cover Waterproofing" shall be made at the unit price bid per each manhole. The price established shall be full compensation for all materials, tools, labor, equipment and incidentals necessary to complete this item of work.

23.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE COVER WATERPROOFING

EA [Manhole]

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

24.0 GROUT CURTAIN WATERPROOFING METHOD

24.1 DESCRIPTION. This section covers waterproofing manholes by installing a grout curtain. When specified or called for on plans, a chemical grout curtain may be installed to prevent infiltration. Ports shall be drilled in a checkerboard fashion in the manhole chimney, corbel, and wall, and a chemical grout pumped into the surrounding soil through the ports surrounding the manhole to create an impermeable "curtain". For brick and block manholes, the procedure may involve the use of a two-coat cementitious liner in combination with the grout curtain.

24.2 CONSTRUCTION METHODS. The manhole surface shall be cleaned, patched, and infiltration stopped prior to continuing with waterproofing. Holes shall be drilled and grout ports or chemical grout injection devices installed to insure proper grouting of the soil outside of the manhole. Some additional ports may be placed after the application of the cementitious liner. Two (2) or 3 coats, as required, of a cementitious liner shall be applied after any chemical grout is pumped. The liner shall provide a dam to optimize the grout sealing application and shall extend from the manhole base to the bottom of the ring seal. The chemical grout gel shall be injected into the soil surrounding the manhole as needed for complete sealing. Grouts injected into near-surface and chimney-corbel areas shall be modified with shrink control agents, gel reinforcing agents and accelerators as needed for the type of chemical gel used.

24.3 METHOD OF MEASUREMENT. Payment for "Grout Curtain" shall be made at the unit price bid per vertical foot of manhole. The price established shall be full compensation for all materials and labor including waterproofing grout, liner materials, surface preparation, application, tools, equipment and incidentals necessary to complete this item of work.

24.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

GROUT CURTAIN

VF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

25.0 INVERT AND BENCH RECONSTRUCTION

25.1 DESCRIPTION. This section covers the reconstruction of invert and bench of manholes. When called for on the plans or specifications, or as directed by the Engineer, manhole benches and inverts shall be reconstructed in accordance with other relevant paragraphs of these specifications. The hydraulic cement shall meet the requirements of the Materials Section.

25.2 METHOD OF MEASUREMENT. Payment for "Invert and Bench Reconstruction" shall be made at the unit price bid per each. The price established shall be full compensation for all materials, labor, tools, equipment, and incidentals necessary to complete this item of work.

25.3 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid for each manhole for which an invert, a bench, or an invert and bench are reconstructed:

INVERT AND BENCH RECONSTRUCTION EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

26.0 CAST-IN-PLACE CONCRETE MANHOLE LINER

26.1 DESCRIPTION. This section covers utilization of an internal forming system for casting a structurally independent 3-inch concrete wall within the existing manhole. The liner is constructed of high-strength concrete in one pour without seams and without disrupting sewer flows.

26.2 MATERIALS

26.2.1 Submittals. The Contractor shall submit test reports of the concrete mix design meeting the requirements of the following sub sections.

26.2.2 General. Unless otherwise specified, the concrete shall be a standard (Type I/Type II) Portland cement mix, ASTM C150, with 3/4-inch minus coarse aggregate, ASTM C33, Size No. 67, producing a minimum 28-day compressive strength of 4000 psi at full cure. When directed by the Engineer, a high-strength, quick-setting cement grout shall be used for positioning and sealing the form at the manhole base.

26.2.3 Forms. Segmented stackable steel forms having cylindrical and conical sections with either eccentric or concentric cones are employed. The assembled internal manhole form shall have sufficient stiffness and strength to preclude shifting and/or collapse during concrete placement and to ensure safe man-entry during the procedure. The assembled form shall have appropriate cross-section size to provide an annular space with a 3-inch average and a 1-1/2-inch minimum thickness.

26.3 CONSTRUCTION METHODS.

26.3.1 Surface Preparation. The Contractor shall use cleaning methods that are adequate to remove loose material from the manhole. All existing manhole steps or ladder are to be removed. The Contractor shall take all necessary precautions to prevent falling debris from damaging the manhole trough and/or entering the sewer. Infiltration through existing manhole walls that would adversely affect the material used in the annular space shall be eliminated or reduced to an acceptable level in accordance with other paragraphs of these specifications.

26.3.2 General. The Contractor shall place block-outs as needed to provide pipe inlets and outlets of the same diameter through the new concrete wall. All flows through the manhole shall remain active unless otherwise directed by the Engineer. The internal form shall be sized, erected and braced as necessary to assure that the new interior wall has an average thickness of 3-inches and not less than 1-1/2-inch minimum. The finished opening shall have a minimum diameter of 20-inch unless otherwise specified. The top of the new concrete interior shall not extend into the manhole ring. The resulting concrete manhole wall shall be smooth and free of honeycomb and areas of segregated aggregate.

26.4 TESTING. A set of 3 concrete cylinders shall be made from each days work with the date, location and job recorded on each. Testing shall be in accordance with ASTM C39. A 28-day compression test will be made and recorded using two (2) of the samples. One (1) sample shall be held by the Engineer should the other 2 fail to meet specifications.

26.5 METHOD OF MEASUREMENT. Payment for "Cast-In-Place Concrete Manhole Liner" shall not be made separately, but is included in the unit price bid for "Manhole Rehabilitation" in accordance with other paragraphs of these specifications.

27.0 CEMENTITIOUS MANHOLE LINER

27.1 DESCRIPTION. This section covers the application of a premixed cementitious blend of binders, materials, aggregates, glass fiber and other additives. After mixing with water, the material is spray applied directly to all interior surfaces of manhole in a 2-coat application with in-between and finish troweling which shall restore structural integrity and provide corrosion protection.

27.2 MATERIALS. Materials which may be employed for this work include the following proprietary pre-blended products or approved equal:

- Strong-Seal MS-2A and MS-2C
- Reliner MSP as manufactured by W.R. Grace Co., Conn.
- EMACO S88C manufactured by Master Builders Technologies, Cleveland, Ohio.
- Quadex QM-1s Reliner manufactured by Quadex Inc., Cabot, Arkansas.

27.3 CONSTRUCTION METHODS. Surface preparation in accordance with the liner manufacturer's recommended procedures. The materials shall be mixed and applied in accordance with the manufacturer's written instructions using approved equipment. The equipment shall be of a type necessary for the application of the proprietary product used as recommended by the manufacturer and approved by the Engineer. When Reliner MSP is used, it shall be in powdered form and all additions must conform to the requirements of ASTM C94. The material shall be spray applied directly to the prepared manhole surface. The material shall be troweled after each coat. All cementitious liner materials, approved herein, shall completely cover the interior surface of the manhole with a minimum thickness of 1/2-inch.

27.4 METHOD OF MEASUREMENT. Payment for "Cementitious Manhole Liner" shall not be made separately, but is included in the unit price bid for "Manhole Rehabilitation".

28.0 CURED-IN-PLACE MANHOLE LINER

28.1 DESCRIPTION. This section covers reconstruction and rehabilitation of sanitary sewer manholes by the installation of a resin impregnated flexible felt tube, inverted into the existing manhole. Cured-In-Place Liner and its minimum thickness shall conform to the requirements of ASTM F1216.

28.2 MATERIALS

28.2.1 Tube. The tube shall be compatible with the resin system and shall consist of one or more layers of flexible felt or an equivalent woven or nonwoven material. The material shall be able to stretch to fit irregular manhole sections. Allowance shall be made in the fabrication of

the tube so that the installed, formed-in-place-pipe fits snugly to the interior circumference of the existing manhole, while allowing for stretching during inversion. The resin shall be of the manufacturer's standard and certified products for this application. The thickness of the installed liner shall have a minimum thickness of 1-inch.

28.2.2 Submittals. The Contractor shall provide cut sheets and data for the tube material and resin along with installation instructions for approval by the Engineer.

28.3 CONSTRUCTION METHODS. The Contractor shall designate a location where the tube will be vacuum impregnated prior to installation. The Engineer shall inspect the materials and the "wet-out" procedure and approve the location. Install in strict accordance with manufacturer's instructions. The liner shall be cut off below the manhole cover and sealed as specified. The finished product shall be continuous over the entire manhole and be free from dry spots, delamination, bulges and warps. It shall also meet the leakage requirements or pressure test specified. During the warranty period, any defects shall be repaired at the Contractor's expense. After the liner has been cured in place, the Contractor shall reconnect the existing pipes entering the manhole. This shall be done from the interior of the manhole by cutting the tube at the pipe openings. If due to broken or misaligned pipe at the manhole wall the tube fails to make a tight seal, the Contractor shall apply a seal at that point.

28.4 METHOD OF MEASUREMENT. Payment for "Cured-In-Place Manhole Liner" shall not be made separately, but is included in the unit price bid for "Manhole Rehabilitation".

29.0 COMPOSITE MANHOLE LINER

29.1 DESCRIPTION. This section covers rehabilitation of sanitary sewer manholes by the installation of a flexible plastic liner with profiled cross section cast into a structurally independent concrete wall.

29.2 MATERIALS

29.2.1 Grout components shall be clean, fresh, and stored in suitable dry condition. Premixed grout and grout admixtures shall be used in accordance with the manufacturer's instructions and approved by the Engineer. The liner shall be PVC Panels or Coils manufactured by Danby of North America, Inc. Columbia, Maryland, or approved equal. The PVC materials shall be made from compounds specified for PVC pipe extrusion suitable for potable water and sanitary sewer and conform to ASTM D1784. The minimum panel base thickness and minimum panel "tee" profile height shall be specified by the Engineer. PVC Sheeting for Permaform Process by Action Products Marketing Corporation of Johnston, Iowa. The plastic liner shall be a white, high-polymer, vinyl chloride sheeting capable of being cast into the concrete, and made an integral part of the structure. It shall have a minimum thickness of 65 mils. HDPE manhole liner system shall be fabricated from polyethylene pipe manufactured by Chevron Spriolite Corporation of Norcross, Georgia in accordance with ASTM F894.

29.2.2 Submittals. Proposed grouting procedure including type of formwork used and/or measures taken to prevent buckling of liner, and cone entry assembly shall be submitted to the Engineer for review and approval. The Contractor shall submit a certificate that the PVC liner furnished under this specification is in conformance with the material and mechanical requirements in the appropriate ASTM and as specified herein. Submittals for concrete mix design shall be in accordance with these specifications.

29.3 CONSTRUCTION METHODS

29.3.1 PVC Panels or Coils.

- **Liner Installation (Panels).** If the Contractor chooses to use the PVC liner in the form of panels, the panels shall be cut and trimmed to fit as near as practical to the internal circumference of the structure. The panels shall be placed commencing at the bottom of the manhole with the male locking edge of the panel to the bottom of the manhole. The bottom edge of the first panel shall be set in a bed of fast-setting grout. The panels shall be kept square with the vertical wall. A bead of selected sealant/adhesive, approved by the Engineer, and of sufficient width to seal the joint shall be applied to the female locking edge and the end-joining piece prior to the locks being engaged. End joints shall be made with a manufacturer supplied/approved plasticized end-joining material which shall under-lap the panels by not less than 3-inches. The end joints shall be staggered so the joints are not aligned. A bead of the approved sealant/adhesive shall be placed over the end joint after panel installation. If necessary, the panels may be shimmed off the wall to avoid discontinuities on the surface, or to achieve a more circular interior wall than the original as may be approved by the Engineer.
- **Liner Installation (Coils).** If the Contractor chooses to use the PVC liner in the form of coils of continuous strip, the liner shall be placed commencing at the bottom of the manhole. The ribbed profile of the strip shall be kept offset from the wall by vertical studs/spacers to maintain annular gap to grout (concrete) thickness specified. The strip is manually spirally wound around the interior of the manhole to a height that will exceed a scribe line on the liner that matches the bottom contour of the manhole by two revolutions. The bottom contour of the manhole is then scribed onto the liner. The liner is then cut along the scribe line so as to fit the interface of the bottom of the manhole and the wall. The liner is then positioned down into a bed of hydraulic cement. A bead of selected sealant approved by the Engineer, of sufficient width to seal the joint shall be applied to the male locking edge prior to the locks being engaged. Additional coils of PVC strip may be introduced by joining the ends of the strip by means of a manufacturer supplied joiner pad; the joint shall be sealed on both sides of the strip with the approved sealant. Alternatively, the ends of successive coils may be joined in a simple lap joint using solvent cement. The strip shall be wound just past the designated liner height. After grouting and grout set, the liner shall be trimmed to the designated height.
- **Grouting.** Once the liner is in place, the hydraulic cement bed at the bottom of the manhole is checked to determine if additional sealing is required. Grout holes may be drilled in the PVC lining at appropriate points and grout pumped into them until satisfactory fill is obtained. When grouting holes are used, the holes shall be sealed with PVC plugs upon grout completion. The grouting plan shall be reviewed and approved by the Engineer in advance of the work. Care shall be taken not to allow the hydrostatic pressure of the fluid grout to buckle with the PVC liner. When required, temporary rigid vertical supports shall be placed on the inner perimeter of the PVC liner while the grout is being placed.
- **Lining of Cone/Corbel.** The materials used in cone/corbel lining shall consist of truncated pie sections made by diagonally cutting two strips of material and inserting these, along the diagonal cut, into a center joiner strip supplied by the manufacturer. After trimming the ends to approximate the circular radiuses of the top and bottom of the cone and sealing all joints with approved sealant, the truncated pie sections shall be fitted

together by interlocking the edges to form the cone lining. The cone lining shall then be braced and grouted after appropriate sealing at the bottom.

29.3.2. Installation of PVC Sheeting.

- Forms shall be sized, erected and braced as necessary to assure that the new interior wall shall have a minimum thickness of 1-1/2-inches extending from the manhole base to the top of the cone section conforming generally to the interior dimensions of the existing structure. When casting a structurally independent wall 3-inches in thickness or greater, an internal diameter of 42-inches shall be maintained in the existing manhole.
- The form shall be positioned, sealed and finished at the manhole base to ensure that concrete does not enter the sewer. The PVC liner shall be fitted securely to the exterior of the steel forms during erection. When the forms are removed, any joints in the liner shall be cleaned and fusion or extrusion welded. When directed by the Engineer, the interior surface including welded joints shall be spark-tested with a holiday detector. Any holidays or defects in the liner shall be repaired and retested.
- The concrete shall be carefully placed in such a manner as to prevent segregation of the cement and aggregate. The concrete shall be consolidated to fill all pockets, seams and cracks within the existing wall. When the concrete has sufficiently cured to preclude slump or damage, the form shall be disassembled and removed.
- Jointing seams in the plastic liner will be fusion welded by qualified personnel using only factory-approved methods and techniques. The welding operation of any joint shall be continuous until that joint has been completed. The welding strip shall be centered over the cleaned surfaces to be joined, and fused across its entire width.

29.3.3 HDPE Liner

- The surrounding roadway material or soil shall be excavated and the existing chimney and cone sections shall be removed. Undamaged precast sections may be salvaged and reused as directed by the Engineer. All debris shall be properly disposed of off site at the contractor's expense.
- The outer diameter of the liner shall not be less than 1-1/2-inches smaller than the the internal diameter of the existing manhole. The liner shall be installed spigot end up and accurately trimmed around the bottom to conform to existing benches and sewer lines. The HDPE liner shall be centered in the manhole and the bottom edge set using Ram-nek or an approved equal as a seal between liner and bench and crown of pipes at bottom of manhole. Pipe stubs shall be installed through the liner wall matching inverts and flow lines, and sealed with an approved mastic before grouting annulus. The pipe material shall be a diameter equal to or slightly larger than the existing pipe.
- Sound construction practice shall be taken in the placement of grout to insure that the annulus is free of voids and the liner is not buckled during the grouting operation. The annulus shall be filled to the bottom of the top rib on the polyethylene liner.
- A polyethylene flat top or cone with bell assembly shall be installed on spigot end of liner and sealed with closure gasket or mastic as directed by the Engineer. The precast cone or

slab and ring sections shall be placed so that they are fully supported by the existing concrete walls leaving an approximately one fourth (1/4") inch space between the polyethylene and precast top sections. The ring or cone section of the liner shall be trimmed so that the frame and lid will be fully supported by the concrete walls. The space between the entry sections shall be grouted. All remaining concrete grout exposed to the sanitary sewer environment shall be coated.

29.5 METHOD OF MEASUREMENT. Payment for "Composite Manhole Liner" shall not be made separately, but is included in the unit price bid for "Sanitary Sewer Manhole Rehabilitation".

30.0 ELASTOMERIC MANHOLE COATING

30.1 DESCRIPTION. This section covers application of elastomeric coatings to the interior surfaces of a manhole to provide a high level of corrosive protection. The coatings may be sprayed, rolled, brushed or applied by trowel as required by the manufacturer. The material shall be suitable for overhead, vertical and horizontal surfaces.

30.2 MATERIALS

30.2.1 Submittals. The Contractor shall submit a certificate that the coating furnished under this specification is in conformance with the material and mechanical requirements in the appropriate ASTM and as specified herein.

30.2.2 General. The coating systems may be one of the following types:

- High-Build Epoxy Coatings. The coating material shall be a 2-part, 100% solids epoxy-resin with fibrous and flake fillers specifically designed for sanitary sewer applications. Use Raven Chemicals Raven 405 High Build Epoxy Coating or approved equal.
- Polyurea Coating Systems. The coating material shall be urethane-based 100% solids resin with chemically resistant fillers specifically designed for sanitary sewer applications. Use Spray-Seal by Structural Polymer Systems or T-C300 by Thane-Coat, Inc, or approved equal.

30.3 CONSTRUCTION METHODS

30.3.1 Surface Preparation. Infiltration shall be stopped and surface thoroughly mechanically cleaned to provide a good bond between the epoxy coating and the substrate. Waterblast with a 5,000 psi stream to remove oil, grease and foreign materials from all surfaces to be coated. In areas where the concrete has become softened due to chemical attack, several millimeters of the wall surface shall be removed. [Use pressures up to 25,000 psi if necessary or as recommended by the coating manufacturer, to ensure that a sound substrate is exposed.]

30.3.2 Application. The material shall be mixed and applied 2 or 3 coats, in accordance with the manufacturer's written instructions, using approved equipment. Use coating primers where required by the manufacturer. The material shall be applied to all interior surfaces of the manhole with a minimum thickness of 100 mils. Allow a minimum of 2 hours cure time before returning the manhole to active flow conditions. After 7-day cure, the liner's surface shall be free of runs, sags, and other irregularities that indicate improper application practice. When directed by the Engineer, liner shall be repaired.

30.4 METHOD OF MEASUREMENT. Payment for "Elastomeric Manhole Coating" shall not be made separately, but is included in the unit price bid for "Sanitary Sewer Manhole Rehabilitation".

31.0 REINFORCED CONCRETE PIPE (RCP)

31.1 DESCRIPTION. This section covers bar-cage reinforced concrete pipe and fittings with O-ring rubber gasketed joints intended to be used for conveyance of sewage and industrial waste. Pipes shall be supplied in nominal diameters forty-two (42") inches and larger. [Other pipe applications for RCP are covered in other specification paragraphs.

31.2 MATERIALS

31.2.1 Submittals. Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted. Such shall include, but shall not be limited, to the following for each size of pipe.

- Data on reinforcement
- Details of joints, fittings and specials
- Test reports
- Laying schedule
- Certification for pipe and protective lining
- Certification and sample of Elastomeric O-ring gasket
- The Contractor shall submit 6 copies of all submittals requested in this specification.

31.2.2 Pipe. All pipe and fittings shall be manufactured in accordance with the following ASTM Standards or as modified herein.

- ASTM C76, Standard Specification "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe".
- ASTM C655, Standard Specifications for "Reinforced Concrete D-Load Culvert, Storm Drain and Sewer Pipe".

31.2.3 Materials. Unless otherwise specified, all materials used in the manufacture of pipe, fittings, and accessories shall conform to ASTM C76 or as modified herein. Except for special design pipe, all concrete sewer pipe shall be tongue-and-groove jointed pipe, conforming to ASTM C76, Wall Type B.

- Fine Aggregate. Fine aggregate shall conform to the requirements of ASTM C33, and shall be clean natural sand.
- Cement. Cement shall conform to the requirements of ASTM C150 containing not more than 5% tricalcium aluminate.
- Gaskets. Gaskets shall conform to requirements of ASTM C361, Section 6.9.1, except minimum tensile strength shall be 1,500 psi, Shore A, hardness shall be 40. Polymer used in the manufacture of gaskets shall be synthetic rubber. Natural rubber will not be acceptable.
- Rubber Joint Filler. Shall be synthetic with hardness 40 plus or minus 5 when measured in accordance with ASTM D2240, Type A durometer.

31.2.4 Minimum Pipe Design. Design, select and specify concrete pipe according to the "Concrete Pipe Design Manual" published by American Concrete Pipe Association. Design for AASHTO HS-20 truck highway live loading and Cooper Axle E-80 Railroad live loading conditions.

31.2.5 Joints. Tongue-and-groove jointed pipe is preferred; bell and spigot jointed pipe is not prohibited but if used shall conform to Section 8 of ASTM C361 except as modified herein. Gaskets shall have a circular cross section and shall be confined in a groove in the pipe spigot. Pipe with collars in lieu of integral bells will not be acceptable. Each concrete pipe joint shall be designed to withstand, without cracking, the gasket compression plus a differential load across the joint equal to 4,000 psf of internal diameter. Pipe sections connecting to manholes shall have a joint in each line within 4 feet of the inside face of each manhole or other structure.

31.2.6 Reinforcement. Circumferential reinforcement shall be full-circle type. Elliptical or part-circle reinforcement shall not be acceptable unless otherwise specified by the Engineer. Longitudinal steel shall be spaced uniformly around the pipe and shall consist of continuous or lap-spliced wires or bars in each cage. The minimum concrete cover over circumferential reinforcement, except under the spigot groove of pipe with concrete spigots, shall be not less than 3/4-inch for pipes less than 60-inch diameter and 1-inch for 60-inch and larger pipes.

31.2.7 Fittings. All bends, tees, closure pieces, wall fittings, and other fittings which are indicated on the drawings or required to complete the work shall be furnished. Except as modified or otherwise provided herein, the design and manufacture of fittings shall be governed by the same requirements as the connecting piping.

- Bends. At the option of the Contractor, bends for concrete sewer pipe shall be fabricated from segments of a steel cylinder with concrete or mortar lining and reinforced concrete exterior covering, or from segments of concrete pipe miter cut while the pipe is still green. The deflection angle between adjacent segments shall not exceed 30°. Steel cylinders for bends shall be at least USS 10 gauge and shall be lined with 3/4-inch concrete or mortar. Bends fabricated from steel cylinders shall be designed for the same three-edge bearing loads as the adjacent piping. Bends fabricated from miter cut segments of green concrete pipe shall have the concrete removed from around the reinforcing steel as necessary, the steel shall be welded, and the concrete shall be replaced. After installation, the entire bend shall be encased in concrete. Concrete encasement shall be at least 8-inches thick all around.
- Wall Fittings. Bell type wall fittings shall be provided at the locations indicated on the drawings. Wall fittings shall be of the required length and shall have bells to match the joints on the concrete pipe.
- Outlets. Fabricated outlet branches shall be provided as indicated on the drawings.
- Closure Pieces. Closure pieces shall be cut in the field after pipe, fittings and specials, as indicated on the drawings, have been installed. The alignment indicated on the drawings shall be maintained by deflecting joints and by adding fittings if necessary. The length between structures and P.I. locations shall be adjusted in the field as required. Closure pieces shall be field cut from full length pieces of pipe. At the option of the Contractor, field cuts may be made with a masonry saw or may be chiseled and neatly trimmed. Field cut ends shall be encased with 8-inch thick collars.

31.2.8 Protective Pipe Lining. Protective lining for reinforced concrete pipe interior surfaces shall be shop coated with

- TNEMEC 46H-413 Hi-Build Tnemec-Tar, 40 mil DFT
- Induron Protecto 401, or approved equal.
- The material manufacturer shall furnish an affidavit attesting to the successful use of their material as a lining for applications where sewage conditions are recognized as corrosive or otherwise detrimental to concrete.

31.3 CONSTRUCTION METHODS

31.3.1 Markings. Each pipe or fitting shall have the date of manufacture, manufacturer's name or trademark, and, on bends, the angle turned thereby, plainly and permanently marked thereon. Markings shall be indented in the pipe or painted with waterproof paint.

31.3.2 Delivery. Prior to delivery to the site, concrete pipe and fittings shall be cured in the manufacturer's facilities until concrete control cylinders representing such pipe have attained a compressive strength of a least 80% of the specified minimum 28-day strength.

31.4 TESTING

31.4.1 Preliminary Tests. All preliminary tests shall be made at the Contractor's expense. Reports covering the following tests on each size of pipe shall be submitted for review. Tests for joint leakage, joint shear and three-edge bearing are for proof of design only. Reports covering tests made on other pipe of the same size, as specified herein, and manufactured from materials of equivalent type and quality, may be acceptable unless otherwise specified by Engineer.

- Joint Leakage. Joint leakage shall be in accordance with ASTM C443, Section 10.
- Joint Shear. Suitable arrangement, to apply the specified loads, shall be provided to protect against joint shear.
- Cement. Mill test report showing tri-calcium aluminate content.
- Three-Edge Bearing. Three-Edge Bearing in accordance with ASTM C497.
- Report load required for 0.01 inch crack and for ultimate strength.
- Absorption. In accordance with ASTM C497 not to exceed 5.5%.

31.4.2 Control Tests. Control tests shall be made during the manufacture of the pipe to determine strength and absorption. Control tests shall be made by an independent testing laboratory at the expense of the Contractor. Strength tests may be made on cores or standard concrete cylinders. Absorption tests shall be made on cores taken from the pipe barrel. Cores shall be made with a diamond drill and shall not be smaller than 2-inches in diameter. One (1) core shall be tested from representative samples of daily production runs. Core holes shall be repaired by cementing a properly shaped concrete plug in place with epoxy cement or by other methods acceptable to the Engineer. The City reserves the right to sample and test any pipe after delivery and to reject all pipe represented by any sample which fails to comply with the specified requirements.

31.5 METHOD OF MEASUREMENT. Reinforced concrete pipe will be measured by the linear foot in place. Payment shall be by the linear foot in place.

31.6 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

REINFORCED CONCRETE PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

32.0. ABANDONING/REMOVING MANHOLE

32.1 DESCRIPTION. This section covers abandoning or removing existing manholes when called for on the plans or specified. This work shall be accomplished following abandoning and plugging existing sewer lines.

32.2 CONSTRUCTION REQUIREMENTS. Abandoning Manhole work shall be accomplished in accordance with the Standard Detail for Abandoning Manholes. The manhole shall be broken down to a point at least 2 feet below proposed or existing grade. Removing Manholes shall be accomplished in accordance with the "Standard Detail for Abandoning Manhole" except the manhole shall be broken down to a point 2 feet below any proposed construction or totally removed when directed by the Engineer. Remaining parts of manhole shall be filled with sand backfill and shall be compacted. Salvaged materials, including ring and cover shall be disposed of by the Contractor.

32.3 BASIS OF PAYMENT. Payment for "Abandoning Manhole" shall be made at the unit bid price per each. The price established shall be full compensation for all materials including sand backfill, labor, tools, equipment and incidentals necessary to complete this item of work. Payment for "Removing Manhole" shall be made at the unit price bid per each when specified as an item of work, otherwise it shall be included in other items. When so classified, the price established for "Removing Manhole" shall be full compensation for all materials including sand backfill, labor, tools, equipment and incidentals necessary to complete this item of work.

ABANDONING MANHOLE EA
REMOVING MANHOLE EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

33.0 VITRIFIED CLAY SEWER PIPE (VCP). Vitrified Clay Pipe is not prohibited neither shall it be routinely deployed without written permission of the City Manager. If so approved, the City Engineer shall provide a special specification for its use.

34.0 DUCTILE IRON PIPE (DIP)

34.1 DESCRIPTION. This section covers Ductile Iron Pipe (DIP) and fittings intended to be used for conveyance of sewage and industrial waste. Pipes may be supplied in sizes ranging from 4 to 60-inches in diameter.

34.2 MATERIALS

34.2.1 Submittals. The Contractor shall submit the following provided that all applicable requirements are met, and that visual inspection at destination shows the workmanship and condition of the material to be satisfactory. All material furnished under certification shall be tagged, stenciled, stamped or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

- Type "A" Certification for pipe
- Type "D" Certification for elastomeric gasket
- Shop drawings of the pipe and joints
- Documentation of an ongoing manufacturer's quality control program
- Submit 6 copies of all submittals requested in this specification.

34.2.2 General. All ductile iron pipe and fittings shall conform to the requirements of the following ASTM Standards listed below or as modified herein.

- ASTM A746, Standard Specifications for Ductile Iron Gravity Sewer Pipe
- AWWA C111/ANSI A21.11, Rubber Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings
- AWWA C150/ANSI A21.60, Thickness Design of Ductile-Iron Pipe
- AWWA C151/ANSI A21.61, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lines Molds, for Water or Other Liquids
- AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances
- Pipe shall be provided on nominal lengths of 20 feet. Pipe joints shall be push-on joints and comply with all applicable requirements of AWWA C111/ANSI A21.11.

34.2.3 Coating and Lining

- Exterior Coating. The exterior of ductile iron pipe, specials and fittings shall be coated with an asphaltic coating in accordance with ASTM A746, Section 6.1. The coating shall have a minimum thickness of 1 mil. The finished coating shall be smooth, continuous and strongly adherent to the pipe. Any damage to the outside coating during shipping, storage, handling and installation shall be field repaired with a fresh coating in accordance with the manufacturer's recommendations.
- Interior Lining. Interior surfaces of pipe and fittings shall be lined with 40 mils of Virgin Polyethylene complying with ASTM D1248, Madison Polyurethane Lining, Corropipe II TX-5 Minute Number 17115, manufactured by Madison Chemicals, Inc., Canada, Induron Protecto 401, or an approved equal.

34.2.4 Minimum Pipe Design. Unless otherwise specified, Ductile Iron Pipe shall have the following nominal thickness, in inches, and pressure class shown in the following table with respect to required cover.

Minimum Ductile Iron Pipe Design Parameters										
Pipe Diameter (ID)	Depth of Cover (feet)									
	10 or <		> 10 - 15		> 15 - 20		> 20 - 25		> 25	
	Nominal Thickness (inches)	Standard Pressure Class AWWA C151	Nominal Thickness (inches)	Standard Pressure Class AWWA C151	Nominal Thickness (inches)	Standard Pressure Class AWWA C151	Nominal Thickness (inches)	Standard Pressure Class AWWA C151	Nominal Thickness (inches)	Standard Pressure Class AWWA C151
3	0.25	360	0.25	350	0.25	350	0.25	350	0.25	350
4	0.25	360	0.25	350	0.25	350	0.25	350	0.25	350
6	0.25	360	0.25	350	0.25	350	0.25	350	0.25	350
8	0.25	360	0.25	350	0.25	350	0.25	350	0.25	350
10	0.26	360	0.26	350	0.26	350	0.26	350	0.26	350
12	0.28	360	0.28	350	0.28	350	0.28	350	0.28	350
18	0.31	260	0.31	250	0.31	250	0.31	350	0.34	300
24	0.33	200	0.33	200	0.33	200	0.38	300	0.38	300
30	0.34	160	0.34	150	0.34	150	0.42	250	0.45	300
36	0.38	160	0.38	150	0.38	150	0.47	250	0.50	300
42	0.41	160	0.41	150	0.41	150	0.52	250	0.63	350
48	0.46	160	0.46	150	0.46	150	0.64	300	0.70	350
54	0.51	160	0.51	150	0.51	150	0.72	300	0.79	350
60	0.54	160	0.56	150	0.54	150	0.76	300	0.83	350
64	0.56	160	0.56	150	0.56	150	0.80	300	0.87	350

34.3 METHOD OF MEASUREMENT. Payment shall be by the linear foot in place.

34.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

DUCTILE IRON PIPE (DIP)(SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

35.0 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

35.1 DESCRIPTION. This section covers High Density Polyethylene (HDPE) pipe and fittings intended to be used for conveyance of sewage and industrial waste.

35.2 MATERIALS

35.2.1 Submittals. Provide cut sheets, material data, manufacturing standards to which the pipe has been fabricated, in 6 copies.

35.2.2 Pipe Materials. The HDPE pipe shall be made of high density plastic compound meeting the requirements of Type III, Class C, Category 5, Grade P34 as defined in ASTM D1248 and with an established hydrostatic design basis (HDB) of not less than 1,600 psi for water at 73.4°F determined in accordance with ASTM Test Method D2837. Materials shall also meet the requirements of cell classification PE 345434C or higher cell classification with light color inside, when classified in accordance with ASTM D3350. HDPE pipes manufactured for trenchless installations such as sliplining, pipe bursting, etc. may be made, entirely or having inside surface, in light color (e.g. natural, white, green, etc.) to allow light reflection for robotic television inspection. Contractor/Manufacturer shall provide certification that the product has sufficient UV stabilizer for a minimum 2 years of storage life.

Property	ASTM Test Method	Minimum Value
Density	D1505	0.941 (gm/cm ³)
Melt Index	D1238	< 0.15 (gm/10 min.)
Initial Flexural Modulus	D790	110,000 psi
Long-Term Flexural Modulus		28,200 psi
Initial Flexural Strength	D790	3,000 psi
Long-Term Flexural Strength		1,500 psi
Hydrostatic Design Basis	D2837	1,500 psi

35.2.3 Solid Wall HDPE Pipe.

- General. All solid wall HDPE pipes may be used for open-cut and sliplining installations, in sizes ranging from 6-inches to 48-inches in diameter, manufactured per ASTM F714.
- Joint System. Sections of polyethylene pipe shall be assembled and joined on the job site. Jointing shall be accomplished by the heating and butt-fusion method in strict conformance with the manufacturer's printed instructions. The butt-fusion method for pipe jointing shall be carried out in the field by operators with prior experience in fusing polyethylene pipe with similar equipment using proper jigs and tools per standard procedures outlined by the pipe manufacturer. These joints shall have a smooth, uniform, double rolled back bead made while applying the proper melt, pressure, and alignment. It shall be the sole responsibility of the Contractor to provide an acceptable water-tight butt-fusion joint.
- Pipe Stiffness. For all open-cut installations, HDPE pipe shall have a minimum pipe stiffness of 46 psi as determined in accordance with ASTM D2412.

35.2.4 Profile Wall HDPE Pipe

- General. All open or closed profile wall HDPE pipe and fittings to be manufactured in accordance with ASTM F894. Pipes shall be supplied in sizes from 18-inches to 72-inches in diameter. Regardless of size, open profile wall pipes will be allowed only on sections of pipe when there are no apparent service connections. Otherwise, open profile wall pipes will not be allowed. Pipe Stiffness. HDPE pipe and fittings shall have a minimum pipe stiffness of 46 psi as determined in accordance with ASTM D2412.

- Joint System. Pipe joining system shall be gasketed type and consist of integrally formed bell and spigot, one which is designed to accommodate a gasket, which when assembled forms a watertight seal by the radial compression. Joints shall provide a watertight seal and meet the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477 and be molded into a circular form or extruded to the proper section, then spliced into circular form, and shall be made of a properly cured high grade elastomeric compound. The basic polymer shall be neoprene, synthetic elastomer, or a blend of both. The gasket shall be designed with an adequate compressive force, so as to effect a positive seal under all combinations of joint tolerances. Natural rubber gaskets will not be acceptable. Lubricate in accordance with the manufacturer's recommendations.

35.3 CONSTRUCTION METHODS

35.3.1 Sliplining. Pipes used for sliplining installations shall meet the following requirements. For existing pipes with a nominal inside diameter (I.D.) less than or equal to 33-inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than 3-inches smaller than the nominal I.D. of the existing pipe. For existing pipes with a nominal I.D. greater than 33-inches, the O.D. of the sliplining pipe shall not be more than 6-inches smaller than the nominal I.D. of the existing pipe.

35.3.2 Solid Wall HDPE Pipes. The HDPE liner pipe shall have the following minimum Standard Dimension Ratio (SDR) for various depths:

Maximum Depth of Cover (feet)	SDR
10	26
15	21
20	19
30	17

The minimum outside diameter (O.D.) of HDPE liner pipe shall be as designated below:

Existing Sewer Line Nominal Inside Diameter (inches)	Minimum O.D. of Liner (inches)
8	7.125
10	8.625
12	10.750
15	12.750
18	16.000
21	18.000
24	22.000
27	24.000
30	28.000
33	30.000
36	32.000
42	36.000
48	42.000

35.3.2 Pipe Bursting, Boring and Tunneling. The HDPE pipe used for these installations shall meet the material requirements and SDR requirements prescribed in other paragraphs of these specifications and have a minimum inside diameter equal to nominal pipe size.

35.4 METHOD OF MEASUREMENT. Will be measured by the linear foot in place.

35.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

HIGH DENSITY POLYETHYLENE (HDPE) PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

36.0 POLYVINYL CHLORIDE (PVC) PIPE

36.1 DESCRIPTION. This section covers polyvinyl chloride (PVC) pipe and fittings intended to be used for conveyance of sewage and industrial waste.

36.2 MATERIALS

36.2.1 Submittals. Provide in 6 copies pertinent pipe data, manufacturer's installation instructions and material certifications.

36.2.2 Solid Wall (PVC). All solid wall PVC pipe and fittings shall conform to the requirements of the appropriate ASTM listed below or as modified herein.

- ASTM D3034 - Standard Specification for "Type PSM Polyvinyl Chloride Sewer Pipe and Fittings". Pipe and fittings shall have a minimum stiffness of 46 psi and a minimum SDR of 35 and a minimum tensile modulus of 500,000 psi per ASTM D1784. Pipe and fittings may be supplied in sizes ranging from 4-inches to 15-inches in diameter.
- Elastomeric Gasketed Joints shall be used to provide a watertight seal and shall meet the requirements of ASTM D-3212.
- ASTM F679 - Standard Specification for "Polyvinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings". Pipe and fittings shall have a minimum stiffness of 46 psi and a minimum SDR of 35. Pipe and fittings may be supplied in sizes ranging from 18-inches to 36-inches in diameter.
- Integral Bell Gasket Joint shall be used to provide a watertight seal and shall meet the requirements of ASTM D3212.

36.2.3 Profile Wall Pipe (PVC). All profile (open or closed) wall PVC pipe and fittings shall conform to the requirements of the appropriate ASTM listed below and modified herein. Regardless of size, open profile wall pipes will be allowed only on sections of pipe when there are no apparent service connections. Otherwise, open profile wall pipe will not be allowed.

- ASTM F794 - Standard Specification for "Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer

Pipe and Fittings Based on Controlled Inside Diameter". Pipe and fittings shall have a minimum stiffness of 46 psi. Pipe and fittings may be supplied in sizes ranging from 12-inches to 48-inches in diameter.

- Gasketed Joint Systems shall be used. The integral bell gasketed joint, coupling or fitting joints shall be designed so that when assembled, the gasket will be compressed radially on the pipe spigot or in the bell to form a watertight seal. The joints shall be designed to comply with and show no leakage when tested in accordance with ASTM D3212.
- Closed profile PVC pipes manufactured with a gasketed joint coupling system, with no bell and spigot, may be used for sliplining installations. Couplings shall form a watertight seal when assembled with plain end pipe and show no sign of leakage when tested in accordance with ASTM D3212.
- ASTM F949 - Standard Specification for "Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings". Pipe and fittings shall have a minimum stiffness of 50 psi. Pipe and fittings may be supplied in sizes ranging from 12-inches to 36-inches in diameter. Elastomeric Gasketed Joints shall be used to provide watertight seal and shall meet the requirements of ASTM D3212.

36.2.4 Special PVC Pipe. Special PVC pipe and fittings shall conform to the requirements of the appropriate standards listed below or as modified herein.

- ASTM D-2241 - Standard Specifications for Polyvinyl Chloride (PVC) Pressure-rated Pipe (SDR Series). Pipe and fittings shall have a minimum SDR of 32 and may be supplied in sizes ranging from 4-inches to 36-inches in diameter.
- Elastomeric gasketed joints meeting the requirements of ASTM D-3212 shall be used to provide a watertight seal.
- AWWA C900 and AWWA C905 - Standards for PVC Pressure Pipe from 4-inches through 12-inches, and 14-inches through 36-inches, respectively. Pipes shall have a minimum DR rating of 18 for diameters through 12-inches. For pipes greater than 12-inches in diameter, the minimum DR shall 32 1/2.
- Elastomeric gasketed joints meeting the requirements of ASTM D3139, when measured in accordance with ASTM2122, shall be used to provide a watertight seal.

36.3 CONSTRUCTION METHODS

36.3.1`Open-Cut, Pipe-bursting, Jacking, Boring and Tunneling, and Micro- or Small Diameter Tunneling operations comply with other paragraphs of these specifications.

36.3.2`Sliplining. PVC pipe shall be manufactured with a gasketed joint coupling system with no bell and spigot providing a watertight seal and meeting the requirements of ASTM D3212. The Contractor shall submit detailed drawings of joints to the Engineer for review and approval prior to manufacturing. Dimensions - Pipes used for sliplining installations shall meet the following general requirements:

- For existing pipes with a nominal inside diameter (I.D.) less than or equal to 33-inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than 3-inches smaller than the nominal I.D. of the existing pipe.
- For existing pipes with a nominal I.D. greater than 33-inches, the O.D. of the sliplining pipe shall not be more 6-inches smaller than the nominal I.D. of the existing pipe. In addition, sliplining pipes shall minimum pipe inside diameter specified and shall meet the following requirements:

Existing Sewer Line Nominal Inside Diameter (inches)	Minimum O.D. of Liner (inches)	Minimum I.D. of Liner (inches)
24	22.110	As Specified on the plans and or contract Documents
27	25.115	
30	28.232	
33	31.415	
36	31.415	
42	37.800	
48	44.200	
64	60.670	

36.4 METHOD OF MEASUREMENT. Will be measured by the linear foot in place. Payment shall be by the linear foot in place.

36.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

POLYVINYL CHLORIDE (PVC) (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

37.0 REINFORCED FIBERGLASS PIPE (RFP)

37.1 DESCRIPTION. This section covers reinforced fiberglass pipe and fittings intended to be used for the conveyance of sewage and industrial waste.

37.2 MATERIALS.

37.2.1 Pipes shall be centrifugally cast, fiberglass-reinforced polyester resin [also known as centrifugally cast fiberglass reinforced polymer mortar pipe] as manufactured by Hobas USA, Inc. or approved equal. The pipe stiffness shall be a minimum of 46 psi when measured in accordance with ASTM D2412 for all installations except jacking. Other pipe stiffnesses may be used when called for on the plans or as directed by the Engineer. All pipes, joints and fittings shall be manufactured in accordance with the requirements of ASTM D3262 or as modified herein. Such pipes may be used in applications 12-inches to 120-inches.

37.2.2 Prior to manufacturing, the pipe supplier shall provide the Engineer with test reports from an independent testing laboratory certifying that the pipe has been tested in accordance with, and

exceeds all minimum requirements of ASTM D2992, ASTM D3262 and ASTM D3681.

37.2.3 Material Elements.

- Resin System. The manufacturer shall use only approved systems for which he can provide a proven history of performance for the intended application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product.
- Glass Reinforcement. The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade of E-glass filaments with binder and sizing compatible with impregnating resins.
- Fillers. Sand may be used as fillers providing that sand shall be a minimum 98% silica with a maximum moisture content of 0.2 percent.
- Additives. Resin additives, such as pigments, dyes, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor shall they impair visual inspection of the finished product.
- Internal Liner Resin - The internal liner resin shall be suitable for service as sewer pipe, and shall be inert to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Provide the certified test results from an independent laboratory that the pipe exceeds the requirements of ASTM D3681.

37.2.4 Dimensions.

- Pipe outside diameters shall be in accordance with AWWA Standards C151 and C950 and as shown below. The minimum wall thickness(es) shown are for a minimum pipe stiffness of 46 psi.

Nominal Pipe Diameter (inches)	Pipe O.D. (inches)	Minimum Wall Thickness (inches)
12	13.20	0.30
16	17.40	0.38
18	19.50	0.42
20	21.60	0.46
24	25.80	0.54
30	32.00	0.66
36	38.30	0.78
42	44.50	0.90
48	50.80	1.02
60	62.90	1.26
66	69.20	1.38
72	75.40	1.50
78	81.60	1.62
84	87.00	1.74
90	94.30	1.86

96	100.60	1.98
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- Pipe shall be supplied in nominal lengths of 10 feet or 20 feet for jacking and 20 feet for all other installations. For sliplining installations, where radius curves in the existing pipe or limitations in the entry pit dimensions restrict the pipe to shorter lengths, nominal sections of 10 feet or 6 feet may be used. All pipe ends shall be square to the pipe axis plus or minus 1/2-inch of the nominal diameter for all pipes diameters.

37.2.5 Jacking Installations. Minimum pipe wall thickness measured at the bottom of the spigot gasket groove where the wall cross-section has been reduced, is determined from the maximum allowable jacking load and shall not be less than as shown in the table below:

Nominal Pipe Diameter (inches)	Pipe O.D. (inches)	Minimum Wall Thickness (inches)
12	13.20	0.39
14	15.30	0.41
16	17.40	0.42
18	19.50	0.44
20	21.60	0.46
24	25.80	0.60
30	32.00	0.68
36	38.30	0.81
42	44.50	1.03
48	50.80	1.10
54	57.10	1.22
60	62.90	1.29
66	69.20	1.32
72	75.40	1.34
78	81.60	1.54
84	87.00	1.76
90	94.30	1.78
96	100.60	1.88

37.2.6 Sliplining Installations. Pipes used for sliplining installations shall meet the following general requirements.

- For existing pipes with a nominal inside diameter (I.D.) less than or equal to 33-inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than 3-inches smaller than the nominal I.D. of the existing pipe.
- For existing pipes with a nominal I.D. greater than 33-inches, the O.D. of the sliplining pipe shall not be more 6-inches smaller than the nominal I.D. of the existing pipe. In addition, sliplining pipes shall minimum pipe inside diameter specified and shall meet the following requirements:

Nominal Pipe Diameter (inches)	RFP Liner O.D. (inches)	Wall Thickness (inches)
12	13.20	0.3
18	15.30	0.34
21	19.50	0.42
24	21.60	0.46
27	25.80	0.54
30	27.00	0.60
33	30.00	0.66
36	32.00	0.66
42	38.30	0.78
48	44.50	0.90
54	50.80	1.02
60	57.10	1.14
66	62.90	1.26
72	69.90	1.38
78	75.40	1.50
84	81.60	1.62
90	87.00	1.74
96	94.30	1.86
102	100.60	1.98

37.2.7 Joints. Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings that utilize elastomeric sealing gaskets for all installations except jacking and sliplining installations. The joints shall meet the performance requirements of ASTM D4161. For sliplining installations, unless otherwise specified, the pipe shall be field connected with low-profile fiberglass bell and spigot joints. The joints shall meet the performance requirements of ASTM D-4161. For jacking installations, unless otherwise specified, the pipe shall be field connected with sleeve couplings or bell spigot joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness. The joint shall have the same outside diameter (O.D.) as the pipe, so when the pipes are assembled, the joints are flush with the outside surface.

37.2.8 Fittings. Where applicable, flanges, elbows, reducers, tees, wyes, laterals, and other fittings shall, when installed, be capable of withstanding all operation conditions. Acceptable configurations include contact molded or mitered fiberglass, properly protected standard ductile iron, fusion bonded epoxy coated steel and stainless steel constructions.

37.3 METHOD OF MEASUREMENT. Will be measured by the linear foot in place.

37.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

REINFORCED FIBERGLASS PIPE (RFP) (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

38.0 STEEL CASING PIPE

38.1 DESCRIPTION. This section covers steel pipe intended to be used as a carrier pipe for sanitary sewer aerial crossings or casing pipe for boring and micro and small diameter tunneling installations.

38.2 MATERIALS

38.2.1 Submittals. Submittals, when requested, the Contractor shall submit the following, provided that all applicable requirements are met, and that visual inspection at destination shows the workmanship and condition of material to be satisfactory. Other submittals shall include

- Certification for material quality of pipes and coatings if applicable
- Shop drawings of pipes, joints and seams

38.2.2 General. Steel pipe shall conform to ASTM A139, Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and Over). The steel material shall be new, smooth wall, carbon steel, Grade B, with minimum 60,000 psi tensile strength, and minimum 35,000 psi yield strength.

- The pipe shall be straight seam pipe, seamless pipe, or spiral weld pipe. For spiral weld pipe, the spiral shall be 100% welded and the weld's height over the outside wall surface shall be equal to or less than 3/16-inch. Steel pipe joints shall be continuously welded with an approved butt weld. The welds shall attain the full strength of the pipe and shall result in a fully watertight section. The welded joints shall conform to the requirements of AWWA C206.
- All steel pipe shall be square cut and shall have a roundness such that the difference between the major and minor outside diameters shall not exceed 3/8-inch. The outside circumference must be within 3/4-inch of nominal.
- Casing Pipe Sizes. Casing size for each nominal line pipe shall be as shown in the table.

Nominal Line Pipe Diameter (inches)	Casing Pipe Inside Diameter (inches)
4	8
6	10
8	14
10	16
12	18
15	24
18	24
24	33
27	36
30	42
36	42 - 48
48	60 - 66

- Casing Pipe Thickness - Steel casing pipe shall the following minimum thickness(es), in inches, for the indicated maximum depth of cover(s), in feet:

Outside Diameter	Under Highways		Under Railroads		
(inches)	Wall Thickness (inches)	Maximum Cover (feet)	BNSF (Uncoated) Wall Thickness (inches)	Union Pacific Wall Thickness (inches)	Maximum Cover (feet)
12 ¾	0.188	30	0.250	0.25	30
16	0.250	30	0.281	0.3125	30
18	0.250	30	0.322	0.322	30
20	0.250	30	0.344	0.344	30
24	0.250	30	0.406	0.406	30
30	0.322	30	0.469	0.469	30
36	0.375	30	0.531	0.531	30
42	0.375	25	0.563	0.563	30
48	0.438	25	0.625	0.625	25
54	0.438	25	0.719	Over 48" Must Be Approved by U.P.R.R.CO.	20
60	0.438	25	0.781		20
66	0.438	20	0.875		20

- Micro and Small Diameter Tunneling. The steel casing pipe minimum wall thickness for micro and small diameter tunneling shall be 1/4-inch.
- Aerial Crossings. The minimum thickness for steel carrier pipe shall be three-sixteenths (3/16) inch and one-fourth (1/4") inch for diameters of forty-two (42") inches and less, and greater than forty- two (42") inches, respectively.

38.2.3 Exterior Protective Coating. Exposed exterior surfaces shall have protective coating, shop applied coal-tar enamel, conforming to the requirements of AWWA C203. The coating thickness shall be 40 mils, applied in 2 coats.

38.3 METHOD OF MEASUREMENT. Will be measured by the linear foot in place. Payment shall be by the linear foot in place.

38.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

STEEL CASING PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

39.0 DEFORMED HIGH DENSITY POLYETHYLENE PIPE

39.1 DESCRIPTION. This section covers reconstruction and rehabilitation of sanitary sewer lines by installation of a deformed High Density Polyethylene (HDPE) extruded pipe. The process shall use steam and air pressure to progressively inflate the deformed HDPE pipe to conform to the existing pipe wall.

39.2 MATERIALS. Materials shall be Class B as defined in ASTM D1248. The minimum cell classification shall be PE 346434D, white color, as defined in ASTM D3350.

39.2.1 Minimum Thickness. Unless otherwise specified, the installed HDPE pipe shall have the following minimum thickness(es), in inches, shown below, meeting the requirements stated in these specifications and appropriate design assumptions.

Pipe Nominal Size (inch)	Depth of Cover (feet)				
	10	> 10 - 15	> 15' - 20	> 20 - 25	> 25
8	0.307	0.358	0.409	0.450	0.487
10	0.383	0.448	0.511	0.562	0.608
12	0.460	0.538	0.613	0.675	0.730
15	0.575	0.672	0.766	0.844	0.912
18	0.690	0.806	0.919	1.012	1.097
21	0.805	0.941	1.072	1.181	1.277
24	0.920	1.075	1.226	1.350	1.460

39.3 METHOD OF MEASUREMENT. Will be measured by the linear foot in place. Payment shall be by the linear foot in place.

39.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

DEFORMED HIGH DENSITY POLYETHYLENE PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

40.0 FOLDED POLYVINYL CHLORIDE (PVC) PIPE

40.1 DESCRIPTION. This section covers reconstruction and rehabilitation of sanitary sewer lines by the insertion of a heated, folded PVC pipe which is then pressurized internally causing it to sequentially unfold and expand against the interior surface of the existing pipe.

40.2 MATERIALS. The installed folded PVC pipe shall meet the performance requirements of ASTM D3034. In addition, the PVC Compound used, shall conform to the properties outlined in ASTM D1784 Classification 12454-B or 12454-C and as outlined below:

Property	ASTM Method	Minimum Value
Pipe Stiffness	D-2412	46 psi
Pipe Impact Strength	D-2444	220 lb/ft
Pipe Flattening	D-3034	60% Deflection
Initial Flexural Modulus	D-790	360,000 psi
Long-Term Flexural Modulus		180,000 psi
Tensile Strength	D-638	6,000 psi

40.2.1 Minimum Thickness. Unless otherwise specified, the installed PVC pipe shall have the following minimum thickness(es), in inches, shown below, meeting the requirements stated in these specifications and appropriate design assumptions.

Pipe Nominal Size (inch)	Depth of Cover (feet)				
	10	> 10 - 15	> 15 - 20	> 20 - 25	> 25
8	0.165	0.193	0.220	0.243	0.262
10	0.207	0.242	0.275	0.303	0.328
12	0.248	0.290	0.330	0.364	0.393
15	0.310	0.362	0.413	0.455	0.493

40.3 METHOD OF MEASUREMENT. Will be measured by the linear foot in place. Payment shall be by the linear foot in place, but not to exceed quantity shown on the plans or called for in the special provisions.

40.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

FOLDED POLYVINYL CHLORIDE (PVC) PIPE (SIZE) LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

40.0 RESIN IMPREGNATED TUBE

41.1 DESCRIPTION. This section covers reconstruction and rehabilitation of sanitary sewer lines by the installation of a resin impregnated flexible felt tube (i.e. Cured-In-Place Pipe)(CIPP), inverted into an existing sewer line.

41.2 MATERIALS.

41.2.1 Tube. The tube shall be compatible with the resin system and shall consist of one or more layers of flexible felt or an equivalent woven or nonwoven material. The material shall be able to stretch to fit irregular pipe sections and conform to changes in alignment. Allowance shall be made in the fabrication of the tube so that the installed CIPP fits snugly to the interior circumference of the existing pipe while allowing for stretching during inversion. Resin impregnated tube shall conform to the requirements of ASTM F1216.

41.2.2 Resin. The resin shall be a thermoset and catalyst type, or an epoxy resin and hardener that is compatible with the inversion process. The cured resin impregnated tube shall meet the minimum physical properties as specified below:

Property	ASTM Method	Minimum Value (psi)	+ Minimum Value (psi)
Initial Flexural Strength	D790	4,500	4,000
Long-term Flexural Strength		2,250	2,000
Initial Flexural Modulus	D790	250,000	400,000
Long-term Flexural Modulus		125,000	200,000

41.2.3 Chemical Resistance. The resin impregnated tube shall be fabricated from materials with when cured shall be chemically resistant to withstand internal exposure to domestic sewage. Chemical resistance testing shall be performed in accordance with Appendix X2. of ASTM F1216 and meet all the requirements specified therein.

41.2.4 Minimum Thickness. Unless otherwise specified, for the materials indicated, the installed resin impregnated tube shall have the following minimum thickness(es), in inches, shown below and the appropriate design assumptions. Should the Contractor propose a resin system that differs from these specifications, he shall submit the proposed physical properties for design and calculated minimum thickness for review and approval by the Engineer. The Engineer shall thereafter establish the appropriate minimum thickness to be furnished and the use of the product.

Pipe Nominal Size (inches)	Depth of Cover (feet)									
	10		> 10 - 15		> 15 - 20		> 20 - 25		> 25 -30	
	? Minimum Thickness (inches)	+ Minimum Thickness (inches)	? Minimum Thickness (inches)	+ Minimum Thickness (inches)	? Minimum Thickness (inches)	+ Minimum Thickness (inches)	? Minimum Thickness (inches)	+ Minimum Thickness (inches)	? Minimum Thickness (inches)	+ Minimum Thickness (inches)
8	0.187	0.153	0.218	0.187	0.249	0.213	0.274	0.235	0.297	0.254
1	0.233	0.191	0.273	0.234	0.311	0.266	0.343	0.293	0.371	0.317
1	0.280	0.229	0.328	0.280	0.373	0.319	0.411	0.352	0.445	0.380
1	0.350	0.286	0.410	0.350	0.467	0.400	0.514	0.439	0.556	0.475
1	0.420	0.344	0.491	0.420	0.560	0.479	0.617	0.627	0.667	0.670
2	0.490	0.401	0.673	0.490	0.653	0.558	0.719	0.615	0.777	0.665
2	0.560	0.458	0.655	0.560	0.746	0.888	0.822	0.703	0.889	0.760
2	0.630	0.515	0.736	0.630	0.839	0.718	0.925	0.791	1.000	0.855
3	0.700	0.573	0.818	0.700	0.933	0.798	1.027	0.879	1.111	0.960
3	0.770	0.630	0.900	0.770	1.026	0.877	1.130	0.966	1.222	1.045
3	0.840	0.687	0.982	0.840	1.119	0.957	1.233	1.054	1.333	1.140
4	0.980	0.801	1.145	0.980	1.306	1.117	1.438	1.230	1.655	1.330
4	1.120	0.916	1.309	1.119	1.492	1.276	1.644	1.406	1.777	1.520
5	1.260	1.030	1.473	1.259	1.679	1.436	1.849	1.581	2.000	1.710

44.0 AERIAL CROSSING.

44.1 DESCRIPTION. This section covers construction of aerial sewer crossing as shown on the plans. Each aerial crossing is defined the entire crossing system and shall include excavation and backfill, construction of reinforced concrete bases and piers, carrier pipe, sewer pipe, and all incidental work. The "Aerial Crossing" shall be defined on the plans between discrete line stations.

44.2 MATERIALS. All pipes, carrier pipes, and components shall conform to the appropriate paragraphs of these specifications. Unless otherwise specified, all concrete used in construction of sanitary sewers and their appurtenances shall have a minimum 28-day compressive strength of not less than 3,500 psi. All steel reinforcement used shall be Grade 60.

44.3 CONSTRUCTION METHODS. Construction of aerial crossings shall be as called for on the plans and in accordance with the "Standard Detail for Aerial Crossing".

44.4 METHOD OF MEASUREMENT. Payment for "Aerial Crossing" shall be made at the unit price bid per lineal foot of pipe for each size. The price established shall be full compensation for materials including excavation, backfill, foundations, piers, reinforced concrete, straps, hardware, gcarrier pipe, sanitary sewer pipe, skid support, plugging pipe, anchor bolts, and all tools, labor, equipment, and incidentals necessary to complete this item of work.

44.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

AERIAL CROSSING (SIZE)	LF
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Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

45.0 SANITARY SEWER CONSTRUCTION STANDARD BID ITEMS

45.1 DESCRIPTION. This section covers Standard Bid Items used in the contract documents for the construction of sanitary sewers and their appurtenances. Additional bid items may be called out in the Special Provisions, other sections of the Standard Specifications, or as directed by the Engineer for additional work covered and change orders.

PARA	DESCRIPTION	UNIT
	SEWER SERVICE CONNECTION	EA.
	RISER PIPE	L.F.
	SEWER SERVICE LINE	L.F.
	PLUGGING ABANDONED SEWER	EA.
	ABANDONING SEWER/ABANDONING MANHOLE	C.Y.
	PIPE BURSTING (SIZE)	L.F.
	SLIPLINING (SIZE)	L.F.
	FORMED-IN-PLACE PIPE (SIZE)	L.F.
	SEWER FLOW CONTROL	L.S.
	CLEANING SEWER LINE	L.F.
	SMOKE TESTING	L.F.
	POINT REPAIR	EA.
	DEFLECTION TEST (SIZE)	L.S.
	DEFLECTION TEST (SIZE)	L.F.
	TELEVISION INSPECTION	STA.
	TELEVISION INSPECTION (CCTV)	L.F.
	SEWER LEAK TEST (SIZE)	L.S.
	SEWER LEAK TEST (SIZE)	L.F.
	SANITARY SEWER MANHOLE	EA.
	EXTRA DEPTH MANHOLE WALL(SIZE)	V.F.
	MANHOLE TESTING	EA.
	SANITARY SEWER MANHOLE REHABILITATION	V.F.
	MANHOLE WATERPROOFING	EA.
	MANHOLE JOINT WATERPROOFING	EA.
	MANHOLE RING WATERPROOFING	EA.
	MANHOLE COVER WATERPROOFING	EA.
	INVERT AND BENCH RECONSTRUCTION	EA.
	REINFORCED CONCRETE PIPE (SIZE)	L.F.
	VITRIFIED CLAY SEWER PIPE (VCP)(SIZE)	L.F.
	DUCTILE IRON PIPE (DIP)(SIZE)	L.F.
	HIGH DENSITY POLYETHYLENE (HDPE) PIPE (SIZE)	L.F.
	POLYVINYL CHLORIDE (PVC) (SIZE)	L.F.
	REINFORCED FIBERGLASS PIPE (RFP) (SIZE)	L.F.
	STEEL CASING PIPE (SIZE)	L.F.
	DEFORMED HIGH DENSITY POLYETHYLENE PIPE (SIZE)	L.F.
	FOLDED POLYVINYL CHLORIDE (PVC) PIPE (SIZE)	L.F.
	RESIN IMPREGNATED TUBE (SIZE)	L.F.
	SPECIAL SANITARY SEWER PIPE (SIZE)	L.F.
	AERIAL CROSSING (SIZE)	L.F.