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SECTION 600

SECTION 600 – SANITARY SEWER CONSTRUCTION

SECTION 600 – GENERAL REQUIREMENTS

600.01 – DESCRIPTION

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

600.01.01 – PREQUALIFICATION

As a minimum, all Contractors and Bidders shall meet the prequalification requirements of the City's Prequalification Board, and be prequalified to perform work in the "Sanitary Sewer ALL Construction" Category. Prequalification for additional categories of work, when required may be specified in the Special Provisions.

600.02 – MATERIALS

Construction materials shall not be delivered to the site of the work more than three (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 three hundred (300) feet of sewer unless with special permission of the Engineer.

Unless otherwise specified, all concrete used in construction of sewers and their appurtenances shall have a minimum twenty-eight (28) day compressive strength of thirty-five (3,500 psi) pounds per square inch and shall conform with the applicable requirements of Section 900. All steel reinforcement used shall be grade sixty (60) with a minimum yield strength of sixty thousand (60,000 psi) pounds per square inch and meet the applicable material requirements of Section 900.

600.04 – 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 eighteen (18) inches in diameter and smaller for more than six hundred (600) feet, and sewers twenty-one (21) inches in diameter and larger for more than three hundred (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 nine hundred (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 as per Section 824 immediately before backfill is completed.

600.04.01 – 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.

600.04.02 – SEWER GRADES

General - 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.

Laser Beams - When laser beams are used to establish line and grade, they shall first be calibrated in accordance with the equipment manufacturers 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.

600.04.03 – 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 twenty-four (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.

600.04.04 – 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 the other pay items.

600.04.05 – 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.

600.04.06 – 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.

SECTION 610 - PIPE INSTALLATION

610.01 - 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.

610.02 – PIPE MATERIALS

610.02.01 - PIPE

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

Pipe Type	Pipe Material	Section
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

610.02.02 - EMBEDMENT MATERIAL

General - Embedment material shall meet the requirements of Section 215. 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.

Invoices - 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.

610.04 – CONSTRUCTION METHODS

610.04.01 – BEDDING AND HAUNCHING

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" and meeting the requirements of Section 215.

Flexible Pipes - All flexible pipes shall be embedded in accordance with ASTM D-2321, "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" and meeting the requirements of Section 215.

610.04.02 - 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 in accordance with Section 212 when 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 pursuant to Section 505.

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. Bell holes shall not be excavated more than ten (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.

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 three-eighths (? ") 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.

After a section of pipe is properly installed and approved for backfill, the trench shall be backfilled and compacted as per section 212.

610.06 – 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.

610.07 - BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SANITARY SEWER PIPE (SIZE) L.F.

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. Embedment material shall be paid for under Section 215.

SECTION 611 – SEWER SERVICE CONNECTION

611.01 – DESCRIPTION

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

611.02 – MATERIALS

611.02.01 – PIPE MAT ERIALS

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

Pipe Type	Pipe Material	Section
Rigid	Vitrified Clay Pipe (VCP)	649
Flexible	* Ductile-Iron Pipe (DIP)	650
	Polyvinyl Chloride (PVC) Pipe	652

* Not to be used for wye branches but for risers only.

611.02.02 – CONNECTION TYPES

The following connection types may be required to make sewer service connections:

External Connections for New Construction

Wye Branches - For new construction there shall be installed wye branches of size and type shown on the plans with a minimum of four inch (4”) openings at locations shown on the plans or as designated by the Engineer.

External Connections to Existing Main - Connections to existing main may be accomplished as follows:

Saddles - 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.

Tees - 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 four inches (4”). The external connections shall be considered complete when backfilling and subsequent surface restoration is completed.

Internal Connections (Reinstatements) – Shall not be allowed.

611.02.03 – RISER

General - Risers shall be connected to sewer pipe using standard wyes, tees or saddles. No services may be connected to sewer pipe that is twenty-one inches (21”) 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

Riser 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 one-fourth inch (1/4") round hairpin bars.

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 two feet (2') above ground. The tape shall be three inch (3") width DuraTec as manufactured by THOR Enterprises, Inc. of Sun Prairie, Wisconsin or approved equal.

611.04 – CONSTRUCTION METHODS

General - 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 forty-five (45º) degrees with the horizontal. One (1) cubic foot of concrete shall be placed around each connection, the cost of which shall be included in other items.

Wye Branches - Sewer Service Connections constructed with wye branches shall include a one-eighth (1/8º) degree bend, elbow, and when required, a closure piece.

Tees - Sewer Service Connections constructed with tees shall include a one-eighth (1/8º) degree bend, and when required, an elbow and a closure piece.

Saddles - Sewer Service Connections constructed with saddles shall include straps, a one-eighth (1/8º) degree bend, and a closure piece.

611.06 – 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 Section 617. 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" as described in Section 612.

611.07 – 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	L.F.

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.

SECTION 612 – SEWER SERVICE LINE

612.01 – 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 four inches (4”).

612.02 – MATERIALS

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

Pipe Type	Pipe Material	Section
Rigid	Vitrified Clay Pipe (VCP)	649
Flexible	Ductile-Iron Pipe (DIP)	650
	Polyvinyl Chloride (PVC) Pipe	652

612.04 – 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.

612.06 – 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.

612.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SEWER SERVICE LINE	L.F.

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.

SECTION 613 - DELETED

SECTION 614 – ABANDONING SEWER

614.01 – DESCRIPTION

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

614.02 – MATERIALS

The materials shall meet the requirements of Section 218.02 for “Flowable Fill Plugs”.

614.06 – 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.

614.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

ABANDONING SEWER C.Y.

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.

SECTION 615 – PIPE BURSTING

615.01 – 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.

615.02 – MATERIALS

615.02.01 – 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.

615.02.01 – PIPE MATERIALS

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

Pipe Type	Pipe Material	Section
Flexible	High Density Polyethylene (HDPE) Pipe	651
	Polyvinyl Chloride (PVC) Pipe	652

615.04 – CONSTRUCTION METHODS

615.04.01 – GENERAL

Where pipe is required to be installed under railroad embankments or under highways, streets, or other facilities by trenchless methods, construction shall be made in such a manner that will not interfere with the operation of the railroad, street, highway, or other facility, and shall 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, until such time as the backfill has been completed and then shall be removed from the site.

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.

615.04.02 – SEWER SERVICE CONNECTIONS

All sewer service connections shall be accomplished and paid for in accordance with Section 611.

615.06 – 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.

615.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

PIPE BURSTING (SIZE) L.F.

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.

SECTION 616 – SLIPLINING

616.01 – 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.

616.02 – MATERIALS

616.02.01 – SUBMITTALS

General - 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.

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 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.

1) Details of the proposed pipe.
2) Properties, strengths, etc. of pipe
3) Details of joints.

Certification of Material Compliance - A signed letter from the manufacturer stating that all material satisfies claims made by the manufacturer and meets the requirements specified. Reports of the plant test including, but not limited to, liner thickness, flexural strength, and flexural modulus shall be submitted. A registered Professional Engineer shall certify submittals.

Insertion or Access Pits - 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.

Sealing Compound and Grout - 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.

Jacking Loads - 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.

Copies - The Contractor shall submit six (6) copies of all submittals requested in these specifications.

616.02.02 – LINER PIPE MATERIALS

Acceptable liner pipe materials are as follows and shall meet the requirements of the appropriate sections indicated below:

Pipe Type	Pipe Material	Section
Rigid	Vitrified Clay Pipe (VCP)	649
Flexible	High Density Polyethylene (HDPE) Pipe	651
	Polyvinyl Chloride (PVC) Pipe	652
	Reinforced Fiberglass Pipe (RFP)	653

616.04 – CONSTRUCTION METHODS

616.04.01 – CLEANING SEWER LINES

Cleaning sewer lines shall be accomplished in accordance with Section 619.

616.04.02 – SEWER FLOW CONTROL

Sewer flow control shall be accomplished in accordance with Section 618.

616.04.03 – POINT REPAIR

Point repairs shall be accomplished in accordance with Section 622. Segments between two consecutive manholes that require more than five (5) point repairs for successful rehabilitation may be deleted, by the Engineer, from the specified work. At the discretion of the Engineer, these segments may be replaced by conventional excavation in accordance with Section 212.

616.04.04 – INSPECTION OR ACCESS PIT EXCAVATION & BAC KFILL

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 and/or right-of-way areas.

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.

Excavation and backfill of insertion or access pits shall be accomplished pursuant to Section 212.

616.04.05 – 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 insure against scarring the liner or breaking the joints. It shall be necessary to use a nose-cone to guide the pipe end past minor obstructions and prevent entry of debris and to 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. A hydraulic or cable operated winching pipe pushing device may be used. The machine operator must 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 stable a nearly inserted joint preventing 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.

616.04.06 – 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, or 3-M 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 twelve inches (12”) or one-half (1/2) the diameter of the pipe, whichever is greater. 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 six inches (6”) wide. The Engineer shall approve the chosen method, including chemicals and materials. The Contractor shall cut the liner so that it extends four inches (4”) 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.

616.04.07 – LINER PIPE GROUTING

D**escription** - 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 an approved equal grouting system. A minimum twenty-eight (28) day compressive strength of the grout shall be one thousand (1,000 psi) pounds per square inch 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 one hundred (100%) percent 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 two (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.

Basis of Payment - The cost of grouting shall be incidental to sliplining for pipes fifteen inches (15") 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.

616.04.08 – SEWER SERVICE CONNECTIONS

All sewer service connections shall be accomplished and paid for in accordance with Section 611.

616.05 – TESTING

616.05.01 – TELEVISION INSPECTION

Television inspection shall be accomplished in accordance with Section 624.

616.05.02 – SMOKE TESTING

Smoke testing shall be accomplished in accordance with Section 620.

616.05.03 – DYE-WATER TESTING

Dye-water testing shall be accomplished in accordance with Section 621.

616.05.04 – SEWER LEAKAGE TESTING

Leakage testing shall be required after liner has been installed and prior to services being re-connected. Leakage testing shall be conducted in accordance with Section 625.

616.05.05 – 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.

616.06 – 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 fifteen (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. Addition of inverts/benches, if none already exist, shall be considered incidental to the cost of "Sliplining".

616.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SLIPLINING (SIZE) L.F.

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.

SECTION 617 – FORMED-IN-PLACE PIPE (FIPP)

617.01 – DESCRIPTION

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

617.02 – MATERIALS

617.02.01 – SUBMITTALS

General - 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 six (6) copies of all submittals requested in these specifications.

617.02.02 – FIPP MATERIALS

Acceptable FIPP materials are as follows and shall meet the requirements of the appropriate sections indicated below:

FIPP Material Type	Section
Deformed High Density Polyethylene (HDPE) Pipe	655
Folded Polyvinyl Chloride (PVC) Pipe	656
Resin Impregnated Tube (i.e. Cured-In-Place Pipe)	657

617.02.03 – 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 F - 1216, 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

Design Parameter	Design Assumption
Height of soil above top of pipe, H	Minimum 10 feet
Height of water above top of 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 load + (R_w) (earth prism load) + Live load
Ovality of original Pipe, q	2%
Factor of Safety, N	2.00
Modulus of soil Reaction, E'_s	700 psi

617.04 – CONSTRUCTION METHODS

617.04.01 – GENERAL

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.

617.04.02 – SEWER SERVICE CONNECTIONS

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 the following:

A) A cracked or collapsed connection

B) Missing pipe segments around the connection

C) Presence of roots

D) Protruding or receding connections

External Connection of services shall be executed as per Section 611.02.02.

All sewer service connections shall be accomplished and paid for in accordance with Section 611.

617.04.03 – SEWER FLOW CONTROL

Sewer flow control shall be accomplished in accordance with Section 618.

617.04.04 – POINT REPAIR

Point repairs shall be accomplished in accordance with Section 622. The Engineer, from the specified work may delete segments between two consecutive manholes that require more than five (5) point repairs or external connections to rehabilitate. At the discretion of the Engineer, these segments may be replaced by conventional excavation in accordance with Section 212.

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 thirteen (13') foot span are accessed with one point repair using whichever method is used to make the connections.

617.04.05 – CLEANING SEWER LINES

Cleaning sewer lines shall be accomplished in accordance with Section 619.

617.05 – FIPP MATERIAL TESTING

617.05.01 – GENERAL

Following the installation for each minimum design thickness, the Contractor shall obtain one (1) 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 three (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, five (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.

Methods - 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.

Penalty - In the event, the material fails to meet the requirements of these specifications, an actual factor of safety against buckling shall be calculated and a penalty shall be assessed in accordance with provisions specified in Section 617.05.05. The actual factor of safety shall be determined using the computed average values of test results and the assumed design parameters and equations specified in Section 617.02.03.

617.05.02 – TELEVISION INSPECTION

Television inspection shall be accomplished in accordance with Section 624.

617.05.03 – SMOKE TESTING

Smoke testing shall be accomplished in accordance with Section 620.

617.05.04 – DYE-WATER TESTING

Dye-water testing shall be accomplished in accordance with Section 621.

617.05.05 – PENALTY

Provided that the computed factor of safety is equal to or greater than the value specified, the penalty is not applicable. The penalty shall be computed as a percentage of the bid unit price for the minimum design thickness represented by the test results, and applied to the total length of a run, in accordance with the following schedule:

Computed Factor of Safety	Penalty (%)
? 2.00	0
1.90 - 1.99	5
1.80 - 1.89	10
1.70 - 1.79	20
1.60 - 1.69	30
1.50 - 1.59	40
1.40 - 1.49	50
1.30 - 1.39	70
1.20 - 1.29	90
< 1.20	100

If the computed factor of safety for a specified design thickness fails to meet the required factor of safety, the following shall apply:

On the run that the sample was taken from, the penalty applies to the entire run. A run shall not be tested more than once.

The Contractor, at his option, may conduct additional tests on one (1) sample from other runs of the same design thickness. If so, the penalty for that run is determined from that test.

For runs not tested, the penalty shall be the highest from the other runs tested.

A run is defined as the full extent of an insertion beginning at a manhole or access point and extending continuously to a designated manhole or termination point. Sample locations for additional testing shall be determined by the Engineer. The Contractor shall be responsible for all costs in securing additional test samples (i.e., point repairs, etc.) and all laboratory costs whether the results are passing or failing. In lieu of penalty, the Contractor may install additional formed-in-place pipe to meet the minimum factor of safety requirement.

617.04.06 – 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.

617.06 – 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.

617.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

FORMED-IN-PLACE PIPE (SIZE) L.F.

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.

SECTION 618 – SEWER FLOW CONTROL

618.01 – DESCRIPTION

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

618.01.01 – 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 that shown below for the respective pipe sizes as measured in the manhole when performing television inspection.

Pipe Nominal Size (inch)	Allowable Depth of Flow (% of pipe diameter)
? 10	20
12 - 24	25
? 27	30

618.01.02 – SEWER FLOW CONTROL FOR ALL OTHER OPERATIONS

General - 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.

Plugging or Blocking - A sewer line plug shall be inserted into the line upstream of the section being worked. The plug shall be so designed that all or any portion of the sewage can be released.

Pumping and Bypassing - 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 twenty-four (24) hour basis, engines shall be equipment in a manner to keep noise to a minimum.

Flow Control Precautions - When flow in a sewer line is plugged, blocked, or bypassed; sufficient precautions must be taken to protect the sewer lines from damage that might result from sewer surcharging. Further, 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.

618.06 – 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.

618.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SEWER FLOW CONTROL L.S.

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.

SECTION 619 – CLEANING SEWER LINE

619.01 – 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.

619.02 – EQUIPMENT

619.02.01 – 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.

619.02.02 – 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 three hundred (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.

619.02.03 – 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 eighteen inches (18”) 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.

619.02.04 – 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 two (2) or more high-velocity nozzles. The nozzles shall be

capable of producing a scouring action from fifteen (15º) degrees to forty-five (45º) degrees in all size lines designated to be cleaned. 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.

619.04 – CONSTRUCTION METHODS

619.03.01 – CLEANING PRECAUTIONS

Satisfactory precautions shall be taken to protect the sewer lines from damage that might be inflicted 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.

619.04.02 – 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. The City shall provide a dumpsite for all debris removed from the sewers during the cleaning operation.

Under no circumstances shall sewage or solids removed therefrom be dumped onto streets or into ditches, catch basins, storm drains, or sanitary sewer manholes.

619.05 – 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.

619.06 – 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.

619.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

CLEANING SEWER LINE L.F.

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.

SECTION 620 – SMOKE TESTING

620.01 – 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.

620.04 – 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 bcate service connection 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.

620.05 – TESTING

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.

620.06 – 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.

620.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SMOKE TESTING L.F.

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.

SECTION 621 – DYE-WATER TESTING

621.01 – 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.

621.04 – 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.

621.05 – TESTING

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.

621.06 – METHOD OF MEASUREMENT

The cost of dye-water testing shall be considered incidental and no additional compensation shall be made for this work and the cost of same shall be included in the other pay items.

SECTION 622 – POINT REPAIR

622.01 – 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.

622.02 – MATERIALS

Acceptable pipe materials and fittings shall meet the requirements of Section 610.02 and 611.

622.04 – CONSTRUCTION METHODS

All point repairs require prior approval of the Engineer. Pipe and fittings for point repairs shall be installed according to the provisions set forth in Section 610. Trench excavation and backfill shall be accomplished in accordance with Section 212.

The length of any point repair shall not exceed thirteen feet (13').

Site cleanup and replacement of trees, shrubs, hedges, and sod shall be in accordance with the appropriate sections of the specifications.

622.06 – 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.

All sod, trees, shrubs, hedges, if required foundation material, and 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.

622.07 – 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.

SECTION 623 – DEFLECTION TEST

623.01 – DESCRIPTION

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

623.05 – TESTING

All test results shall be signed and sealed by a Professional Engineer registered in the state of Oklahoma. The test shall be performed not less than thirty (30) days after backfill has been placed. The maximum allowable deflection shall not exceed five (5%) percent of the pipe's base internal diameter (Base ID). Base ID for PVC pipes shall be calculated from measurements taken in accordance with ASTM D 2122 and according to procedures outlined in Appendix XI of ASTM D 3034. For PE pipes Base ID shall be calculated from measurements taken in accordance with ASTM D 2122 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.

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 twenty-four inch (24”) 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 (±) one-thousandth (0.001”) inch. The manual measurement of the vertical internal diameter shall be taken at the centerline of the installed pipe.

623.06 – METHOD OF MEASUREMENT

Payment for "Deflection Test" shall be made at the unit price bid per lump sum for pipes smaller than twenty-four inches (24”) and per lineal foot for pipes twenty-four inches (24”) 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.

623.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

DEFLECTION TEST (< 24”)	L.S.
DEFLECTION TEST (= 24”)	L.F.

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.

SECTION 624 – TELEVISION INSPECTION

624.01 – 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.

For large-diameter sewer inspections, 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 twenty-seven inches (27”) 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.

624.03 – 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 hundred (100) humidity.

Lighting shall be suitable to allow a clear picture of the entire periphery of the main sewer pipe. For large-diameter twenty-seven inches (27”) and larger] pipe, the camera lens shall have not less than a sixty-five (65º) degree viewing angle. A radial viewing camera with a three hundred and sixty (360º) degree vertical rotation and a two hundred and seventy (270º) degree 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 angel 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 three (3) lux with a light color in the twenty-two hundred (2200º) to thirty-two hundred (3200º) degree Kelvin range shall be provided. Auxiliary lighting acceptable to the Engineer shall be provided for large diameter pipe. For diameters of sixty inches (60”) and greater, a minimum of one million (1,000,000) candlepower lighting in the thirty-two hundred (3200º) degree 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.

624.04 – CONSTRUCTION METHODS

624.04.01 – 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.

624.04.02 – PROCEDURE

Pre-work Submittals For Inspection Of Large Diameter Pipes - For pipes twenty-seven 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.

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 date as well as the overall listing of proposed inspection methods in each area.

Remote Inspections - Remote pipe inspections shall be permitted in cases where conditions are, as determined by the Engineer, to be unsafe or impractical for manual inspections, and where acceptable picture quality can be obtained by the Contractor.

The main sewer shall be cleaned as directed by the Engineer and in accordance with Section 619 of grease, roots and debris that may hinder movement of inspection equipment through the lines. Major line obstructions that require point repairs are excluded.

The maximum flow depth for remote inspection work in pipes twenty-four inches (24”) and less is twenty (20%) percent of the pipe diameter.

For large pipe diameters [twenty-seven inches and greater], the maximum flow shall be thirty (30%) percent 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 forty (40º) degrees Fahrenheit.

CCTV inspection shall be done one manhole section at a time and the flow in the section being inspected shall be suitably controlled as specified in Section 624. 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 thirty (30) feet per minute. Caution shall be taken to not linger in one spot allowing the heat generated from the unit to ignite roots, debris, etc.

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 twenty-five feet (25') 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.

Manual (Walk Through) Inspections - Manual inspections shall be required in lines where conditions will allow the Contractor's inspection crew to safely walk through the sewer. In general, lines sixty inch (60") in diameter and larger, and having flow depths of less than twenty (20%) percent 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 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. Camcorders shall not be permitted for use as the sole means of obtaining video records.

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, thirty-five (35mm) millimeter color photographs shall be obtained as instructed by the Engineer or as deemed necessary by the in-pipe technicians to document line conditions.

624.05 – DOCUMENTATION

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.

If preliminary inspection occurs in conjunction with a rehabilitation or replacement project, no construction activities shall begin without prior review and subsequent approval by the Engineer of the work outlined in the submittals.

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 insuring 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 Ine 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.

Five (5) complete copies of the final project reports shall be submitted to the City within fifteen (15) calendar days of completion of all field activities. One of the five (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.

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 progress 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 twenty-four 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 dvd format or a format specified by the Engineer. Each tape 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 rerecorded at the Contractor's expense.

Photographs - All photographs taken during manual, walk-through inspections shall be properly mounted and labeled on eight and one half by eleven (8.½" x 11") inch paper for inclusion in the final project reports. One (1) copy of the final reports shall contain the original thirty-five (35) millimeter photos, on fully laminated pages, and the remaining requested copies shall contain copier of pages of these photos. 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.

624.06 – 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)" 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.

624.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

TELEVISION INSPECTION (CCTV) L.F.

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.

SECTION 625 – SEWER PIPE LEAKAGE TESTING

625.01 – 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 twenty-four inches (24”) 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 one inch (1”) diameter pipe installed horizontally through the upstream manhole wall with a clear plastic tube connected to the pipe and extending vertically.

625.05 – TESTING

625.05.01 – 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 ten (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.

625.05.02 – 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 five foot (5’) higher than the top of the pipe or five feet (5’) 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 twelve (12) hours prior to testing. The total exfiltration shall not exceed ten (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 two (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.

625.05.03 – 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.

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.

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 twenty-five (25 psi) pounds per square inch gauge. The sealed pipe shall be pressurized to five (5 psi) pounds per square inch 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 two and one third (2 1/3). 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 twenty-five (25 psi) pounds per square inch gauge. Low-pressure air shall be introduced into this sealed line until the internal air pressure reaches four (4 psi) pounds per square inch gauge. At least two (2) minutes shall be allowed for the air pressure to stabilize. After the stabilization period (three and one half (3 ½ psi) pounds per square inch gauge minimum pressure in the pipe), 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 three and one half (3 ½ psi) to two and one half (2 ½ psi) pounds per square inch gauge is not less than that shown in the following table:

Table 625.05.01 – Air Test Requirements

Pipe Nominal Size (Inches)	Minimum Test Time (min:sec)	Length for Minimum Time (Feet)
6	2:50	751
8	3:47	564
10	4:43	450
12	5:40	376
15	7:05	302
18	8:30	250
21	9:55	215
24	11:20	188
27	12:45	167
30	14:10	150
33	15:35	138
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
78	36:50	58
84	39:40	54
90	42:35	51
96	45:20	47

For lengths in excess of "Length for Minimum Time" given in table above, additional testing time to be added to the "Minimum Test Time" is determined from the following equation:

$t = 0.011 (d^2) (L)$; where:

t = additional testing time, seconds

d = nominal pipe diameter, inches

L = additional length, feet

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

625.06 – METHOD OF MEASUREMENT

Payment for "Sewer Leakage Test" shall be made at the unit price bid per lump sum for pipes smaller than twenty-four inches (24”) and per lineal foot for pipes twenty-four inches (24”) 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.

625.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SEWER LEAKAGE TEST (SIZE)	L.S. (<24”)
SEWER LEAKAGE TEST (SIZE)	L.F. (=24”)

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.

SECTION 626 – SANITARY SEWER MANHOLES

626.01 – DESCRIPTION

This section covers construction of sanitary sewer manholes, zero (0’) to six (6’) feet deep. Manholes may be constructed of the following types at locations specified or directed by the Engineer:

A) Precast Reinforced Concrete

B) Cast-In-Place Non-Reinforced Concrete

626.02 – MATERIALS

626.02.01 – PRECAST REINFORCED CONCRETE MANHOLES

General - This specification covers construction of precast reinforced concrete manhole base sections, riser sections (walls) and appurtenances in accordance with ASTM C-478 Standard Specification for "Precast Reinforced Concrete Manhole Sections" and as modified herein.

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

1) Concrete cylinder compressive test results as per ASTM C-478.
2) Amount and detail layout of steel reinforcement as per ASTM C-478.
3) Type "D" Certification for the specified protective coating.
4) Daily log of applied protective coating per Part "J".
5) Affidavit of compliance with these specifications.

Types - Components of manholes shall be as follows:

1) Precast Risers and Grade Rings - Precast risers and grade rings shall be cylindrical type.
2) Precast Tops - Precast tops shall be of the following two types:
    a) Concentric cone
    b) Eccentric cone
3) Precast Base Sections - Base section types shall be as follows:
    a) Base riser section and separate base slab with Mastic sealer.
    b) Base riser section with integral floor and preformed socket to accept a rubber ring.

Sizes - The standard internal diameter of a manhole shall be four feet (4’). Non-standard internal diameters of five feet (5’), six feet (6’), and seven feet (7’) may be constructed when specified or called for on the plans.

Dimensions - The manholes shall be constructed pursuant to the appropriate "Standard Details for Precast Reinforced Concrete Manholes", and/or as specified in ASTM C-478. The minimum wall thickness shall be as specified in the following table or not less than one-twelfth (1/12) of the internal diameter of the largest cone or riser section or five (5”) inches, whichever is greater.

TABLE 626.02.01 – Manhole Diameter and Wall Thickness

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

Materials - All materials for construction of manholes shall be in accordance with Section 6 of ASTM C-478.

Design - Design including concrete properties, reinforcement type and grade, joints, manufacturing and physical requirements shall be in accordance with Section 7 to 10 of ASTM C-478.

Base slabs or floors shall have a minimum riser thickness of six (6”) inches for diameters up to and including forty-eight (48”) inches and a thickness of eight (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 C-478.

Handling - All lifting holes shall be repaired with a mixture of cement and sand grout firmly packed.

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.

For every manhole coated as required, a daily log shall be kept indicating the date, weather conditions, size and identification numbers of manholes coated, and number of gallons of coating applied to each manhole. The average number of gallons applied per manhole shall be equal to or exceed the manufacturer's recommended coverage rate for the coating.

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 C-478, 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, and the test results of compressive strength performed on cores and cured cylinders in accordance with Section 7 of ASTM C-497.

626.02.02 – CAST-IN-PLACE NON-REINFORCED CONCRETE MANHOLES

General - This specification 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), shall be constructed in accordance with the dimensions and requirements of the standard details.

Types - Manholes may be constructed of the following three (3) types, when called for on the plans:

1) Concentric Manholes

2) Eccentric Manholes

3) Offset Manholes

Sizes - The standard manhole size shall be four (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 eight (8") inches.

Dimensions - The manholes shall be constructed pursuant to the appropriate "Standard Details for Cast-In-Place Non-Reinforced Concrete Manholes".

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

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

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.

626.02.03 – 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 one half (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.

626.03.04 – MANHOLE RING AND COVER

General - 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, dorosit, 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 A-48, Class "30 B" for rings and "35 B" 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, 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 one-eighth (1/8") inch in any direction. Wording and markings on covers shall be in accordance with the Standard Details.

Rings - Rings may be manufactured in accordance with the "Standard Detail for Reversible Manhole Ring".

Covers -

1) General - 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.

2) Coating - When called for on the plans or specified, the underside of all manhole covers shall be given one (1) coat of asphalt varnish after visual inspection and approval on the job site.

626.04 – CONSTRUCTION METHODS

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 six (6) inches thick. Placement of material and material properties shall comply with Section 626.

Backfilling - Backfilling for all manholes shall conform to the requirements of section 212.

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.

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".

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 shoved joints 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.

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.

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 four (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.

Extra Depth Manhole Wall - Where required to construct manholes beyond a depth of six (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".

626.05 – TESTING

626.05.01 - MANHOLE INSPECTION

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.

626.05.02 - MANHOLE TESTING

Manhole testing shall be accomplished in accordance with Section 627.

626.06 – METHOD OF MEASUREMENT

Payment for "Sanitary Sewer Manhole" shall be made at the unit price bid per each size for a depth of zero (0') to six (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. 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.

Extra depth shall be measured from the invert to within six feet (6') below top of cover.

626.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

(SIZE) SANITARY SEWER MANHOLE (0'-6')	EA.
EXTRA DEPTH MANHOLE WALL	V.F.

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.

SECTION 627 – MANHOLE TESTING

627.01 – 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.

627.05 – TESTING

627.05.01 – 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.

Manhole Depth (feet)	Maximum Allowable Water Loss
? 8	One (1") inch over Five (5) minutes
> 8	One-eighth (?") inch per vertical Foot of depth over five (5) minutes

627.05.02 – 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 ten inches (10") Hg shall then be drawn on the manhole and the time measured for the vacuum to drop to nine inches (9") Hg. The time measured shall be not less than that shown on the following table.

TABLE 627.05.01 – Manhole Diameter and Time Measured

Manhole Internal Diameter (feet)	Time Measured (seconds)
4	60
5	60
6	60
7	70

627.06 – METHOD OF MEASUREMENT

Payment for "Manhole Testing" shall be made at the unit price called out on plans. The price established shall be full compensation for all material, labor, tools, equipment, and incidentals necessary to complete this item of work.

627.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE TESTING	LS. (< 24")
MANHOLE TESTING	EA. (= 24")

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.

SECTION 628 – SANITARY SEWER MANHOLE REHABILITATION

628.01 – 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:

A) Plugging, patching, and waterproofing of the manhole structure, (including manhole chimney, corbel/cone, wall, and base with mortars), coatings and sealants to improve the surface condition, eliminate infiltration, and provide corrosion protection.
B) Lining or coating of manholes.
C) Cleaning Manholes
D) Reconstruction of benches and inverts

E) Repair or rebuilding of the manhole chimney and corbel to improve structural condition when excavation is required.
F) Removal of steps or ladder
G) Reinstallation or replacement of manhole rings and covers for grade adjustment, ring alignment, or inflow elimination.
H) Elimination of infiltration/inflow under manhole rings.
I) Elimination of inflow through and around manhole covers.

628.04 – CONSTRUCTION METHODS

628.04.01 –SEWER FLOW CONTROL

Manhole sewer flow control shall be accomplished in accordance with Section 618.

628.04.02 – CLEANING MANHOLES

Prior to any rehabilitation work on manholes, all concrete and masonry surfaces shall be cleaned to the satisfaction of the Engineer. Grease, laitance, loose bricks, mortar, unsound concrete, and other materials shall be completely removed. Water blasting with a minimum of five thousand (5,000 psi) pounds per square inch 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.

628.04.03 – MANHOLE WATERPROOFING

Waterproofing of manholes shall be accomplished in accordance with the requirements of Section 630 to 634.

628.04.04 – PATCHING

General - 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.

Material - 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 thirty (30) minutes [ASTM C-191] with a maximum volume change of 0.02% percent [ASTM C-596] and designed to resist freeze-thaw environments. One-hour compressive strength shall be a minimum of two hundred (200 psi) pounds per square inch [ASTM C-109] and the ultimate compressive strengths shall be a minimum of five thousand (5000 psi) pounds per square inch [ASTM C109]. Bond strength shall be a minimum of one hundred and forty-five (145 psi) pounds per square inch [ASTM C-321].

If patching material is used in combination with a liner material, the products shall be deemed compatible as determined by the manufacturer. The following materials have been approved for use in accordance with the manufacturer's recommendations.

Strong-Seal QSR
IPA Systems Octocrete

Method - 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 one sixteenth (1/16”) inch in width shall be routed out to a minimum width and depth of one half (1/2”) inch and patched with non-shrink patching mortar.

Epoxy grouts may be used for filling cracks and voids less than two (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.

628.04.05 – INVERT AND BENCH RECONSTRUCTION

Invert and bench reconstruction shall be accomplished in accordance with Section 635.

628.04.06 – RAISING MANHOLE

Raising manhole shall be accomplished in accordance with Section 457.

628.04.07 – LOWERING MANHOLE

Lowering manhole shall be accomplished in accordance with Section 458.

628.04.07 – RESETTING EXISTING MANHOLE RING AND COVER

Resetting existing manhole ring and cover shall be accomplished in accordance with Section 459.

628.04.08 – SETTING NEW MANHOLE RING AND COVER

Setting new manhole ring and cover shall be accomplished in accordance with Section 460.

628.04.09 – DELETED

628.04.10 – REHABILITATION METHOD

Manhole 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.

Rehabilitation Methods	Section
Cast-In-Place Concrete Manhole Liner	636
Cementitious Manhole Liner (Spray Applied)	637
Cured-In-Place Manhole Liner	638
Composite Manhole Liner (Grouted)	645
* Elastomeric Manhole Coatings	646

* Note: This rehabilitation method may be used only on manholes that do not have exposed rebars or bricks missing.

628.04.11 – SERVICE CONNECTIONS

All services connections shall be reinstated.

628.05 – TESTING

628.05.01 – MANHOLE TESTING

When called for on the plans or specified, manhole testing shall be accomplished in accordance with Section 627.

628.06 – 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.

628.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SANITARY SEWER MANHOLE REHABILITATION V.F.

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.

630 – MANHOLE WATERPROOFING

630.01 – 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.

630.02 – MATERIALS

630.02.01 – GENERAL

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.

630.02.02 – MANHOLE WATERPROOFING MATERIALS

General - After cleaning and preparing surface in accordance with Section 628.04.02, 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 Section 630.

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 one (1) minute. Ten (10) minute compressive strength shall be approximately five hundred (500 psi) pounds per square inch.

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

A) Chemical Grout Materials

1) **General -** All chemical grout or sealant shall comply with EPA requirements for performance attributes for a sewer sealant. In addition, they shall have the following

characteristics:

a) While being injected, the chemical sealant must be able to react/perform in the presence of water (groundwater);

b) The cured material must withstand submergence in water without degradation;

c) The resultant sealant (grout) formation must prevent the passage of water (infiltration) through the sewer joint;

d) The sealant material, after curing, must be flexible as opposed to brittle;

e) In place, the sealant formation should be able to withstand freeze/thaw and wet/dry cycles without adversely affecting the seal;

f) The sealant formation must not be biodegradable;

g) The cured sealant shall be chemically stable and resistant to the mild concentrations of acids, alkalis, and organics found in normal sewage;

h) Packaging of component materials must be compatible with field storage and handling requirements. Packaging must provide for worker safety and minimize spillage during handling;

i) Mixing of the component materials must be compatible with field operations and not require precise measurements of the ingredients by field personnel;

j) Cleanup must be done without inordinate use of flammable or hazardous chemicals;

k) residual sealing materials must be easily removable from the sewer line to prevent reduction or blockage of the sewage flow.

2) **Types** - The Contractor may use one of the following chemical waterproofing materials, or an approved equal:

a) **Acrylamide and Acrylic Base Gels** - Acrylamide and Acrylic Base Gels shall meet the following requirements:

(i) A minimum of ten (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;

(ii) The ability to tolerate dilution and react in moving water during injection;

(iii) A viscosity of approximately two (2) centipoise which can be increased with additives;

(iv) A constant viscosity during the reaction period;

(v) 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;

(vi) A reaction (curing) which produces a homogeneous, chemically stable, non-biodegradable, flexible gel;

(vii) The ability to increase mix viscosity, density, and gel strength, by the use of additives.

b) **Polyacrylamide Base Gel** - Polyacrylamide Base Gel shall meet the following requirements:

(i) A minimum of ten (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;

(ii) The ability to tolerate some dilution and react in moving water during injection;

(iii) A viscosity of thirty to thirty-five (30-35) centipoise at ten (10%) percent solids as applied. The ability to increase mix viscosity, density and gel strength by use of additives;

(iv) A controllable reaction time from ten (10) seconds to five (5) minutes;

(v) A reaction (curing) which produces a homogeneous, chemically stable, non-biodegradable, firm, flexible gel;

(vi) A resistance to degradation over a pH range of two (2) to ten (10);

(vii) A non-hazardous viscous liquid having ACUTE ORAL/RAT and Desnal/Rabbit LD60 greater than thirty-two (32) g/kg and sixteen (16) g/kg, respectively;

(viii) The ability to use water to clean packers and pumps.

c) **Urethane Base Gel -** Urethane Base Gel shall meet the following requirements:

(i) One (1) part urethane prepolymer thoroughly mixed with between five (5) and ten (10) parts of water by weight;

(ii) A liquid prepolymer having a solids content of seventy-seven (77) to eighty-three (83%) percent, specific gravity of 1.04 (8.65 pounds per gallon), and a flash point of twenty degrees F (20°);

(iii) A liquid prepolymer having a viscosity of six hundred (600) to twelve hundred (1200) centipoise at seventy (70) degrees F that can be pumped through five hundred (600) feet of one-half (1/2) inch hose with a one thousand (1000) pounds per square inch head at a flow rate of one (1) ounce per second;

(iv) The water used to react the prepolymer should have a pH of five (5) to nine (9);

(v) A cure time of eighty (80) seconds at forty (40°) degrees F, fifty-five (55) seconds at sixty (60°) degrees F, and thirty (30) seconds at eighty (80°) degrees F when one (1) part prepolymer is reacted with eight (8) parts of water only;

(vi) A cure time that can be reduced to ten (10) seconds for water temperatures of forty (40°) degrees F to eighty (80) degrees F when one (1) partprepolymer is reacted with eight (8) parts of water containing a sufficient amount of gel control agent additive;

(vii) A relatively rapid viscosity increase of the prepolymer/water mix. Viscosity increases from about ten (10) to sixty (60) centipoise in the first minute for one (1) to eight (8) prepolymer/water ratio at fifty (60°) degrees F;

(viii) A reaction (curing) which produces a chemically stable and non-biodegradable, tough, flexible gel; (9) The ability to increase mix viscosity, density, gel strength and resistance to shrinkage by the use of additives to the water.

(ix) The following materials have been approved for use in accordance with the manufacturer's recommendations:

Avanti International AV - 100
Strata Tech ST 502, 510, or 520 Injection Resin
De Neef Hydroacting Seal Foam
Preco Industries' Preco Plus
Scotch-Seal Brand Chemical Grout 5600 or 5610

3) **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 two (2) coat or three (3) coat system shall be able to withstand a hydrostatic pressure of seven (7 psi) or thirty (30 psi) pounds per square inch, respectively, without any visible leaks.

a) The following material has been approved for use in accordance with the manufacturer's recommendations:

Tammstech Hey'Di Special System

630.04 – CONSTRUCTION METHODS

A) Grout Waterproofing Method

1) **Equipment** - 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.

2) **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 devises 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 meeting the requirements of Section 628.04.04. Small leaks may be sealed without drilling and with grout delivered directly into the site with a caulking applicator.

3) **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.

4) **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 then one-sixteenth (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 two (2) coats (of contrasting colors) shall be applied to manholes zero (0’) to fifteen (15’) feet, and three (3) coats applied to depths greater than fifteen feet (15’). 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.

630.05 – TESTING & 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 to the Engineer's satisfaction.

630.06 – 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.

630.07 – 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.

SECTION 631 – MANHOLE JOINT WATERPROOFING

631.01 – 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.

631.04 – CONSTRUCTION METHODS

Chemical Grout Sealing - Chemical grout sealing shall be accomplished in accordance with Section 630.04.

Cementitious Sealing - Cementitious sealing shall be accomplished in accordance with Section 630.04.

Expanded Gasket - Elastomeric polyurethane resin-soaked oakum method, using dry twisted jute oakum or resin rod with polyurethane resin (water activated) may be used.

Manufactured Seal - Manufactured manhole joint seal that generally conforms to the requirements of Section 632 with a stainless steel restraining hoop may be used. Detailed installation procedures shall be in accordance with the manufacturer's instructions.

631.05 – TESTING

Inspection and testing of waterproofing shall be accomplished in accordance with Section 630.05.

631.06 – 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.

631.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE JOINT 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.

SECTION 632 – MANHOLE RING WATERPROOFING

632.01 – DESCRIPTION

This section covers manhole ring waterproofing.

632.01.01 – GENERAL

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 through these areas throughout a twenty (20) year design life. The seal shall remain flexible, allowing repeated vertical movements of the frame due to frost lift, ground movement, or other causes of up to two (2) inches and/or repeated horizontal movement of the frame due to thermal movement of pavement or other causes of up to one-half (1/2) inch.

632.04 – CONSTRUCTION METHODS

632.04.01 – GENERAL

Manhole ring waterproofing shall be accomplished by the following methods as directed by the Engineer.

A) Manufactured Chimney Seal

1) **General** - This product cannot be used on cones or where chimneys are "out of round" by more than two (2”) inches. If the flexible portion of the seal is made of a rubber type product, it shall have a minimum thickness of three-sixteenth (3/16”) inch, a minimum unexpanded width of eight (8”) inches, and be fabricated from a high-grade rubber compound conforming to the applicable requirements of ASTM C-923. 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 sixteen (16) gauge sheet, if channeled, or five-sixteenth (5/16”) inch diameter, if round, stainless steel conforming to ASTM A-240, Type 304, for sheet and ASTM A-479, Type 304, for rods. Any screws, bolts or nuts used on these bands shall be stainless steel conforming to ASTM F-593 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.

2) **Installation** - 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.

B) Applied Ring Seal - An applied seal is one that is achieved by applying a product, approved by the Engineer, 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 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 two (2) concentric rings of two (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 one hundred (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.

632.04.02 – SETTING EXISTING OR NEW MANHOLE RING AND COVER

Setting of the manhole ring and cover shall be in accordance with ring seal manufacturer's instructions.

632.05 –TESTING

Inspection and testing of waterproofing shall be accomplished in accordance with Section 630.05.

632.06 – 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 Section 626.07.

632.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE RING 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.

SECTION 633 – MANHOLE COVER WATERPROOFING

633.01 – DESCRIPTION

This section covers the waterproofing of manhole covers.

633.01.01 – GENERAL

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

633.04 – CONSTRUCTION METHODS

A) **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 two thousand (2,000) pounds per square inch with a hardness (durometer of sixty (60) ± five (5). The cover gasket shall be provided with an outside rib and have a minimum thickness of three-thirty seconds (3/32) inch.

B) 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 fifty (50°) degrees F to two hundred forty-five (245°) degrees F. The manhole insert shall have a minimum thickness of one-eighth (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. The insert shall have a corrosion-resistant strap installed within the bowl for ease of installation and removal. The manhole insert shall be fully seated upon the manhole ring and cover replaced to complete the installation.

633.05 – TESTING

Inspection and testing of waterproofing shall be accomplished in accordance with Section 630.05.

633.06 – 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.

633.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

MANHOLE COVER 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.

SECTION 634 – GROUT CURTAIN WATERPROOFING METHOD

634.01 – DESCRIPTION

This section covers waterproofing manholes by installing a grout curtain.

634.01.01 – GENERAL

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 is 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 as described in Section 637 in combination with the grout curtain.

634.04 – CONSTRUCTION METHODS

634.04.01 – SURFACE PREPARATION

The manhole surface shall be cleaned, patched, and infiltration stopped in accordance with Section 628.

634.04.02 – GROUT PORTS OR INJECTORS

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.

634.04.03 – WATERPROOF COATING

Two (2) or three (3) coats, as required, of a cementitious liner shall be applied as required 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.

634.04.04 – CHEMICAL SEALING

Chemical grout gel shall be injected into the soil surrounding the manhole as needed for complete sealing, using the same equipment and procedures as required earlier in this section. 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.

634.06 – 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.

634.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

GROUT CURTAIN V.F.

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.

SECTION 635 – INVERT AND BENCH RECONSTRUCTION

635.01 – 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 applicable requirements of Section 626. Hydraulic cement shall meet the requirements of Section 628.04.04.

635.06 – 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.

635.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

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.

SECTION 636 – CAST-IN-PLACE CONCRETE MANHOLE LINER

636.01 – DESCRIPTION

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

636.02 – MATERIALS

636.02.01 – SUBMITTALS

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

636.02.02 – GENERAL

Unless otherwise specified, the concrete shall be a standard (Type I/Type II) Portland cement mix, ASTM C-150, with three-fourth (3/4") inch minus coarse aggregate, ASTM C-33, Size No. 67, producing a minimum twenty-eight (28) day compressive strength of four thousand (4000 psi) pounds per square inch 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.

636.02.03 – 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 three (3") inch average and a one and one-half (1 ½") inch minimum thickness.

636.04 – CONSTRUCTION METHODS

636.04.01 – SURFACE PREPARATION

The Contractor shall use cleaning methods that are adequate to remove loose material from the manhole in accordance with Section 628. 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 Section 630 to 634.

636.04.02 – 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 three (3") inches with a one and one-half (1 ½") inch minimum, extending from the manhole base to the bottom of the corbel/cone. The wall thickness may decrease to a minimum of one and one-half (1 ½") inches at the top of the corbel/cone and through the chimney portion of the manhole. The finished opening shall have a minimum diameter of twenty (20") inches unless otherwise specified.

The form shall be positioned, sealed and finished at the manhole base using cement grout to assure that concrete does not enter the sewer during the procedure. As the concrete is placed, it shall be

consolidated to assure that it makes contact with the form and fills all pockets, seams and cracks within the annular space. The Contractor shall use adequate but not excessive vibration that might cause segregation of the concrete components. The top of the new concrete interior shall not extend into the manhole ring.

When the concrete has sufficiently cured to preclude slump or damage, the form shall be removed. The resultant concrete manhole wall shall be smooth and free of honeycomb and areas of segregated aggregate.

636.05 – TESTING

A set of three concrete cylinders, three (3") inch by six (6") inch, shall be made from each days work with the date, location and job recorded on each. Testing shall be in accordance with ASTM C-39. A laboratory shall make the cylinders for testing. A twenty-eight (28) day compression test will be made and recorded using two (2) of the samples. One (1) sample shall be held for further instructions by the Engineer should the other two (2) fail to meet the specifications for the twenty-eight (28) day compression test.

636.06 – 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" per Section 628.

SECTION 637 – CEMENTITIOUS MANHOLE LINER

637.01 – 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 two (2) coat application with in-between and finish troweling which shall restore structural integrity and provide corrosion protection.

637.02 – MATERIALS

The material may be the following proprietary pre-blended product or approved equal:

A) **Strong-Seal MS-2A and MS-2C** - A mixture of Portland cement, chemically-active aggregates, glass fibers and other additives specifically selected for special properties as manufactured by StrongLite Products Corporation of Pine Bluff, Arkansas and designated Strong Seal MS-2A or MS-2C. Unless otherwise specified or called for on the plans, MS-2C shall be used.

B) **Reliner MSP** - A mixture of cementitious and pozzolantic materials, microsilica one hundred (100%) percent virgin polypropylene fibers, and other additives as manufactured by Standard Cement Materials, Houston, Texas. The "fume silica" shall be Force ten thousand (10,000) Microsilica as manufactured by W.R. Grace Co., Conn.

C) **EMACO S88C** - A mixture of Portland cement, specially graded aggregates, synthetic fibers, and admixtures as manufactured by Master Builders Technologies, Cleveland, Ohio.

D) **Quadex QM-1s Reliner** - A cementitious material enhanced with Donna Fill, a fine-graded granite aggregate as manufactured by Quadex Inc., Cabot, Arkansas.

E) **Physical Properties** - The cementitious liner shall have the following minimum properties at twenty-eight (28) days:

	Test Method	Minimum Value
Compressive Strength	ASTM C-495	3,000 psi
Tensile Strength	ASTM C-496	300 psi

Flexural Strength	ASTM C-293	600 psi
Shrinkage	ASTM C-596	0%
Bond	ASTM C-321	130 psi
Density, when applied		105 pcf

637.03 – 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.

637.04 – CONSTRUCTION METHODS

637.04.01 – SURFACE PREPARATION

Surface preparation shall comply with Section 636.04.01 and the liner manufacturer's recommended procedures.

637.04.02 – APPLICATION

The materials shall be mixed and applied in accordance with the manufacturer's written instructions using approved equipment. When Reliner MSP is used, it shall be in powdered form and all additions must conform to the requirements of ASTM C-94. 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 one-half (1/2) inch.

637.05 – TESTING

Testing shall be done in accordance with Section 636.05.

637.06 – METHOD OF MEASUREMENT

Payment for "Cementitious Manhole Liner" shall not be made separately, but is included in the unit price bid for "Manhole Rehabilitation" as per Section 628.

SECTION 638 – CURED-IN-PLACE MANHOLE LINER

638.01 – 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 F-1216.

638.02 – MATERIALS

A) **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.

B) **Resin -** The resin shall conform to the requirements of Section 657.02.

C) **Minimum Physical Properties** - The cured resin impregnated tube shall conform to the requirements of Section 657.

D) **Chemical Resistance** - The resin impregnated tube shall conform to the requirements established in Section 657.

E) **Minimum Thickness** - The installed liner shall have a minimum SDR of 60 and shall meet the

following minimum thicknesses for various manhole internal diameters.

Internal Diameter (feet)	Minimum Thickness (inch)
4	0.80
5	1.00
6	1.20
7	1.40

F) **Submittals** - The Contractor shall provide appropriate submittals in accordance with Section 617.02.01.

638.04 – 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.

The wet-out tube shall be installed in the manhole using a top inversion. The inversion ring shall be built above the top of the manhole to an elevation required to create the standpipe section.

The tube shall be banded to the inversion ring with the impermeable plastic membrane side out and inverted through the ring with a minimal amount of water. The inversion shall be continued with a minimal amount of water until the tube reaches the bottom of the manhole.

After the inversion is completed, the water shall be pumped out if required, and personnel should enter the manhole to manually adjust the tube to fit smoothly against the manhole wall. The tube shall then be filled with water to the predetermined level and the curing process shall begin.

The Contractor shall then supply a suitable heat source and water recirculation equipment. The equipment shall be capable of uniformly raising the water temperature to a level required to effectively cure the resin.

The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the tube and the manhole at or near the bottom to determine the temperature during cure. Water temperature in the manhole during the cure period shall be as recommended by the resin manufacturer.

Initial cure shall be deemed to be completed when inspection of the exposed portions of the tube appear to be hard and sound and the temperature sensor indicates that the temperature is of a magnitude to realize an exotherm. The cure period shall be of a duration recommended by the resin manufacturer and may require continuous recirculation of the water to maintain the temperature.

The Contractor shall cool the hardened tube to a temperature below one hundred (100°) degrees F before relieving the hydrostatic head in the inversion standpipe. Cool down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being pumped out of the manhole.

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 and lifts. 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 as designated by the Engineer. 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 in accordance with section 617.04.

638.06 – 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" as per Section 628.

SECTION 645 – COMPOSITE MANHOLE LINER

645.01 – 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 three (3") inches thick or as directed by the Engineer.

645.02 – MATERIALS

645.02.01 – 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 Section 636.02.01.

645.02.02 – GENERAL

A) **Grout or Concrete** - 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 grout or concrete shall conform to the requirements of Section 636.02.01.

B) **PVC Liner -** The liner shall be of the following types or approved equal:

1) **PVC Panels or Coils** - PVC Panels or Coils shall be as manufactured by Danby of North America, Inc. Columbia, Maryland. The PVC materials shall be made from compounds specified for PVC pipe extrusion suitable for potable water and sanitary sewer, and DWV (Drain/Waste/Vent) with less than ten (10%) percent fillers and shall conform to ASTM D-1784, cell classifications 12454-B, or 13364-A, or 13364-B. The minimum panel base thickness and minimum panel "tee" profile height of the PVC panels shall be as follows, unless otherwise specified by the Engineer:

Dimensions	Minimum Size (inches)
Base Thickness	0.06
"Tee" Profile Height	0.40

2) **PVC Sheeting** - PVC Sheeting shall be as manufactured 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 sixty-five (65) mils, and shall be capable of resisting strong acid, alkaline and salt solutions. It shall be Amer-Plate 95Y T-Lock or equal.

3) **HDPE Liner** - HDPE manhole liner system shall be fabricated from polyethylene pipe manufactured in accordance with ASTM F-894. The liner shall have a minimum ring stiffness constant (RSC) of 63, and meet the material requirements of Section 651 as

manufactured by Chevron Spirolite Corporation of Norcross, Georgia.

645.04 – CONSTRUCTION METHODS

645.04.01 – PVC PANELS OR COILS

A) **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. The locks shall be snapped together. End joints shall be made with a manufacturer supplied/approved plasticized end-joining material which shall under-lap the panels by not less than three (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

B) **Liner Installation (Coils)** - If the Contractor chooses to use the PVC liner in the form of a one hundred fifty (150') foot - two hundred (200') foot coil 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. Winding then proceeds upward with the ribbed profile of the strip spaced from the wall as required. If necessary, the strip may be shimmed off the wall to avoid discontinuities of the wall surface. 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. The locks shall be snapped together with a rubber mallet or other means approved by the manufacturer. Additional coils of PVC strip may be introduced by joining the ends of the strip by means of a manufacturer supplied joiner pad inserted on the ribbed side of the strip. The joint shall be sealed on both sides of the strip with the approved sealant and pinned with a nylon fastener if required. Alternatively, the ends of successive coils may be joined in a simple lap joint by grinding off the "T's" on one end and overlapping the other end piece by three (3") to four (4") inches and joining the two with PVC solvent cement. The edge locks on the lapped piece shall be removed also and these locks shall be aligned on both edges at the mating ends. This process shall be done above ground with adequate ventilation. 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.

C) **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. At the top and around the liner shall be placed a series of tubes that act as grout injection tubes. Alternatively or in addition, 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.

D) **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.

645.04.02 – 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 one and one half (1 ½") 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 three (3") inches in thickness or greater, an internal diameter of forty-two (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 at fifteen thousand (15,000) to twenty thousand (20,000) volts. 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 using a hot air welding gun producing temperatures ranging between five hundred (500°F) and six hundred (600°F) degrees F.

645.04.03 – 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 exceed ninety-seven (97%) percent of 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 in accordance with Section 646.

645.05 – TESTING

Testing shall be done in accordance with Section 636.05.

645.06 – 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" as per Section 628.

SECTION 646 – ELASTOMERIC MANHOLE COATING

646.01 – 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.

646.02 – MATERIALS

646.02.01 – 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. The ambient temperatures at time of application shall be recorded and submitted to the Engineer.

646.02.02 – GENERAL

The coating systems may be one of the following types:

A) High-Build Epoxy Coatings - The coating material shall be a two (2) part, one hundred (100%) percent solids epoxy-resin with fibrous and flake fillers specifically designed for sanitary sewer applications. The coating material shall have the following minimum properties as listed below:

	Test Method	**Minimum Value**
* Tensile Strength	ASTM D-638	8,000 psi
* Tensile Elongation	ASTM D-638	20%
* Compressive Strength	ASTM D-2240	80 Shore D
+ 25% Sulfuric Acid	ASTM C-267	¤ 28 days
* Solids by Volume		100%

* System cured for 7 days at 25° C
\+ Topping cured for 3 weeks at 25° C
¤ Days without deterioration after continuous contact with fresh chemical at 25° C

The following coating system has been approved for use in accordance with the manufacturer's recommendations:

	Product
Raven Chemicals, Tulsa, Oklahoma	Raven 405 High Build Epoxy Coating

B) Polyurea Coating Systems - The coating material shall be urethane-based one hundred (100%) percent solids resin with chemically resistant fillers specifically designed for sanitary sewer applications. The coating material, tested at 25°C, shall have the following minimum properties as listed below:

	Test Method	Minimum Value
* Tensile Strength	ASTM D-412	1,800 psi
* Recoverable Elongation	ASTM D-412	300%
* Surface Hardness	ASTM D-2240	80 Shore A
+ 20% Sulfuric Acid	ASTM C-267	¤ 28 days
* Solids by Volume		100%

The following coating systems have been approved for use in accordance with the manufacturer's recommendations:

	Product
Structural Polymer Systems, Inc., Chicago, IL	Spray-Seal
Thane-Coat, Inc., Houston, TX	T-C 300

646.04 – CONSTRUCTION METHODS

646.04.01 – SURFACE PREPARATION

Infiltration shall be stopped and surface preparation shall be accomplished in accordance with Section 636.04.01. Mechanical cleaning shall be done to provide a good bond between the epoxy coating and the substrate. Waterblasting with a minimum of five thousand (5,000 psi) pounds per square inch shall be done to remove oil, grease and foreign materials from all surfaces to be coated. For brick manholes, use a minimum of six thousand (6,000 psi) pounds per square inch of water pressure. In areas where the concrete has become softened due to chemical attack, several millimeters of the wall surface shall be removed using water pressures of twenty-five thousand (25,000 psi) pounds per square inch to thirty-five thousand (35,000 psi) pounds per square inch, or as recommended by the coating manufacturer, to ensure that a sound substrate is exposed. Surfaces shall be made damp or dry as required by the manufacturer before application of coating system begins.

646.04.02 – APPLICAT ION

The material shall be mixed and applied, in two (2) or three (3) coats, in accordance with the manufacturer's written instructions, using approved equipment. When applying a Polyurea coating, all surfaces to be coated shall be primed as required by the manufacturer. The material shall be applied to all interior surfaces of the manhole with a minimum thickness of one hundred (100) mils.

The Contractor shall allow a minimum of two (2) hours cure time before returning the manhole to active flow conditions or as recommended by the manufacturer. After seven (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 following the manufacturer's recommendation and to the Engineer's satisfaction.

646.06 – 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" as per Section 628.

SECTION 647 – REINFORCED CONCRETE PIPE (RCP)

This Section is for Sanitary Sewer only. See Section 453 and 945 for other applications.

647.01 – 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 forthy-two (42") inches and larger.

647.02 – MATERIALS

647.02.01 – 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. The drawings and data shall include, but shall not be limited, to the following for each size of pipe.

A) Data on reinforcement
B) Details of joints
C) Details of fittings and specials
D) Test reports
E) Laying schedule
F) Type "A" Certification for pipe and protective lining
G) Type "D" Certification and sample of Elastomeric O-ring gasket
H) Documentation of an ongoing manufacturer's quality control program

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. The Contractor shall submit six (6) copies of all submittals requested in this specification.

647.02.02 – PIPE

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

1) ASTM C-76, Standard Specification "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe".
2) ASTM C-655, Standard Specifications for "Reinforced Concrete D-Load Culvert, Storm Drain and Sewer Pipe".

Except for special design pipe, all concrete sewer pipe shall be ASTM C-76, Wall Type B and shall conform to Section 647.02.04. Except for fittings and closure pieces, each pipe shall be not less than seven and one half (7 ½') feet long.

647.02.03 – MATERIALS

Unless otherwise specified, all materials used in the manufacture of pipe, fittings, and accessories shall conform to ASTM C-76 or as modified herein.

A) **Fine Aggregate** - Fine aggregate shall conform to the requirements of ASTM C-33, and shall be clean natural sand. Artificial or manufactured sand will not be acceptable.
B) **Cement** - Cement shall conform to the requirements of ASTM C-150 containing not more than five (5%) percent tricalcium aluminate.
C) **Gaskets** - Gaskets shall conform to requirements of ASTM C-361, Section 6.9.1, except minimum tensile strength shall be fifteen hundred (1,500 psi) pounds per square inch, Shore A, hardness shall be forty (40). Polymer used in the manufacture of gaskets shall be synthetic rubber. Natural rubber will not be acceptable.
D) **Rubber Joint Filler** - Rubber joint filler shall be synthetic.
E) **Hardness** - Hardness shall be forty (40) plus or minus (±) five (5) when measured in accordance with ASTM D-2240, Type A durometer.
F) **Tensile Strength** - Tensile strength shall be twelve hundred (1,200 psi) pounds per square

inch minimum.

647.02.04 – MINIMUM PIPE DESIGN

A) **Design Basis** - Reinforced Concrete Pipes are designed using procedures outlined in Concrete Pipe Design Manual published by American Concrete Pipe Association. The minimum pipe designs provided herein are for AASHTO HS-20 truck highway live loading and Cooper Axle E-80 Railroad live loading conditions.

The designs are based on ordinary clay backfill with kμ' of 0.130 and a unit weight of one hundred twenty (120 pcf) pounds per cubic foot, Class "B" Bedding Installation and the maximum trench width specified in Section 212.04.02.

B) **Highways** - Minimum pipe classes for diameter forty-two (42”) inches to one hundred and two (102”) inches meeting the requirements of ASTM C-76 shall be as follows:

Maximum Depth of Cover (feet)	Minimum Class
10	III
15	IV
25	V

For maximum depth of cover of thirty (30’) feet, pipes ranging from forty-two (42”) inches to fifty-four (54”) inches in diameter shall be designed and manufactured in accordance with ASTM C-655 and shall have the following minimum three-edge bearing strength for 0.01 inch crack ($D_{0.01}$) in pounds per lineal foot per foot of inside diameter:

Pipe Nominal Size (inches)	$D_{0.01}$ (lb/lineal foot per foot of inside diameter)
42	3450
48	3300
54	3125

Pipes ranging in diameter from sixty (60”) inches to one hundred and two (102”) inches shall be Class V for a maximum depth of cover of thirty (30’) feet when manufactured in accordance with ASTM C-76.

C) Railroads - Minimum pipe classes for E-80 Railroad live load for pipe size forty-two (42”) inches to one hundred and two (102”) inches in diameter meeting the requirements of ASTM C-76, or ASTM C-655 shall be as follows:

? Maximum depth of cover ten (10’) feet - Diameters forty-two (42”) inches to one hundred two (102”) inches shall be Class IV.

? Maximum depth of cover fifteen (15) feet - Diameters forty-two (42”) inches shall be Class V and diameters forty-eight (48”) inches to one hundred two (102”) inches shall be Class IV.

? Maximum depth of cover twenty (20’) feet - Diameters forty-two (42”) inches to one hundred two (102”) inches shall be Class V.

? Maximum depth of cover twenty-five (25’) feet - Diameters forty-two (42”) inches to one hundred two (102”) inches shall be Class V.

? Maximum depth of cover thirty (30’) feet - Diameters forty-two (42”) inches to sixty (60”) inches shall have the following $D_{0.01}$.

Pipe Nominal Size (inches)	$D_{0.01}$ (lb/lineal foot per foot of inside diameter)
42	3550

Pipe Nominal Size (inches)	$D_{0.01}$ (lb/lineal foot per foot of inside diameter)
48	3400
54	3225
60	3100

Diameters sixty-six (66”) inches to one hundred and two (102”) inches shall be Class V.

647.02.05 – JOINTS

Joints shall be formed concrete bell and spigot types, conforming to Section 8 of ASTM C-361 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 four thousand (4,000 psf) pounds per foot of internal diameter.

Pipe sections connecting to manholes shall have a joint in each line within four (4’) feet of the inside face of each manhole or other structure.

647.02.08 – REINFORCEMENT

Circumferential reinforcement shall be full-circle type. Elliptical or part-circle reinforcement shall not be acceptable unless otherwise specified by the Engineer. The total area of longitudinal steel shall be not less than two-tenths (0.2%) percent of the concrete cross sectional area of the pipe. Longitudinal steel shall be spaced uniformly around the pipe and shall consist of at least eight (8) continuous or lap-spliced (20 bar diameters for deformed bars or 40 bar diameters for smooth bars) wires or bars in each cage. Splices shall not be welded.

At least three (3) circumferential bars shall be provided in each pipe bell. The bars shall be placed with one and one-half (1 1/2) times the socket depth from the end of the pipe and shall be equal in area to an equivalent length of the outside cage in the pipe barrel. The end circumferential bar shall be placed one inch (1) from the face of the bell. The inside cage (or the single cage) in the pipe barrel shall be extended to within one inch (1) of the end of the spigot.

The minimum concrete cover over circumferential reinforcement, except under the spigot groove of pipe with concrete spigots, shall be not less than three-fourths (3/4”) inch for fifty-four (54”) inch and smaller pipes or one (1”) inch for sixty (60”) inch and larger pipes.

647.02.09 – FITTINGS

A) **General** - 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.

B) **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 thirty (30°) degrees.

Steel cylinders for bends shall be at least USS ten (10) gauge and shall be lined with concrete or mortar at least three quarters (3/4”) inch thick. 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 eight (8”) inches thick all around and shall extend the full length of the bend.

C) **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.

D) **Outlets** - Fabricated outlet branches shall be provided as indicated on the drawings.

E) **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 in reinforced collars at least eight (8”) inches thick and extending eighteen (18”) inches on each side of the field cuts in accordance with Section 610.

647.02.10 – PROTECTIVE LINING

Protective lining for reinforced concrete pipe shall be as follows:

Pipes Forty-two (42) Inches and Smaller - Interior surfaces of pipe shall be shop coated with a total dry film thickness of not less than 40 mils of coal tar epoxy or approved equal.

The coating material shall be TNEMEC 46H-413 Hi-Build Tnemec-Tar, or an 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 a corrosive or otherwise detrimental to concrete. Coating materials shall be stored, mixed, applied and cured in accordance with guidelines set by the manufacturer.

A daily log shall be kept indicating the date, weather conditions, size and identification numbers of pipe joint coated, and number of gallons of coating applied. The average number of gallons applied shall be equal to or exceed the manufacturer's recommended coverage rate for the coating.

Pipes Forty-two (42”) Inches and Greater - T-Lock liner shall be installed on all inside perimeter, three hundred sixty (360°) degrees. The T-Lock shall be premanufactured plastic lining material (either molded or extruded) for application to reinforced concrete sewer pipe and employing a plastic sheet with T-Lock ribs for mechanical bond to the interior surface of the pipe. This liner shall be a minimum of sixty-five (65) mils thick and as per Ameron "Amerplate T-Lock" or an approved equal. All linings shall be tested to be pinhole free over the extent of the lining.

647.04 – CONSTRUCTION METHODS

647.04.01 – MARKING

Each pipe or fitting shall have the following information plainly and permanently marked thereon. Markings shall be indented in the pipe or painted thereon with waterproof paint.

A) Date of manufacture
B) Manufacturer's name or trademark
C) On bends, the angle turned thereby

647.04.02 – 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 eighty (80%) percent of the specified minimum twenty-eight (28) day strength.

647.05 – TESTING

647.05.01 – 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.

A) Joint Leakage - Joint leakage shall be in accordance with ASTM C-443, Section 10.
B) Joint Shear - Suitable arrangement, to apply the specified loads, shall be provided to protect against joint shear.
C) Cement - Mill test report showing tri-calcium aluminate content.
D) Three-Edge Bearing - Three-Edge Bearing shall be accomplished in accordance with ASTM C-497. The reports shall indicate load required for 0.01 inch crack and for ultimate strength.
E) Absorption - Absorption test shall be accomplished in accordance with ASTM C-497. Absorption shall not exceed 5.5 percent (5.5%).

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.

647.05.02 - 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.

At the option of the Contractor, strength tests may be made on cores or standard concrete cylinders. A set of two (2) cores or four (4) cylinders shall be taken from each day's production and every time the concrete mix is changed. One-half (1/2) of the samples shall be tested at seven (7) days or earlier to determine when the pipe has attained sufficient strength for delivery. The remainder shall be tested at twenty-eight (28) days.

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 two (2”) inches in diameter. One (1) core shall be tested from each of the first three (3) lengths of pipe of each size. Thereafter, cores shall be tested from five (5%) percent of the pipe produced, but not less than one (1) from each day's production.

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.

647.06 – METHOD OF MEASUREMENT

Reinforced concrete pipe 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.

647.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

REINFORCED CONCRETE PIPE (SIZE) L.F.

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.

SECTION 648 - ABANDONING/REMOVING MANHOLE

648.01 - 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.

648.02 - CONSTRUCTION REQUIREMENTS

A) **Abandoning Manhole** - This work shall be accomplished in accordance with the Standard Detail for Abandoning Manholes. The manhole shall be broken down to a point two (2') feet below proposed or existing grade.

B) **Removing Manhole** - This work shall be accomplished in accordance with the "Standard Detail for Abandoning Manhole" except the manhole shall be broken down to a point two (2') feet below any proposed construction or totally removed when directed by the Engineer.

C) **Construction** - Manhole shall be filled with sand backfill and shall be compacted in accordance with the requirements of Section 212.

Salvaged materials, including ring and cover shall be disposed of by the Contractor.

648.07 - 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 the cost of "Manhole" as per Section 626.

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.

SECTION 649 – VITRIFIED CLAY SEWER PIPE (VCP)

649.01 – DESCRIPTION

This section covers vitrified clay pipe and fittings intended to be used for the conveyance of sewage and industrial waste. Pipe may be supplied in sizes ranging from four (4”) inches to forty-two (42”) inches.

649.02 – MATERIALS

649.02.01 – SUBMITTALS

The Contractor shall submit the following:

A) Type "A" Certification for pipes and Type "D" Certification for fittings shall be prepared by the manufacturer and shall consist of a certified copy of a report covering tests conducted by an approved laboratory. Tests performed shall be sufficient to determine the conformance of the material to the Standard Specifications. Such tests shall have been conducted on samples obtained from the lot or lots of material in the shipment.

B) Tests results for Three-Edge Bearing Tests, Hydrostatic Tests, Joint Tests, Joint Leakage, Absorption, and Compressive Strength Tests.

C) The Contractor shall submit six (6) copies of all submittals requested in this specification.

649.04 – CONSTRUCTION METHODS

649.04.01 – OPEN-CUT CONSTRUCTION

A) **General** - All vitrified clay pipes and fittings shall be extra strength and conform to the requirements of the appropriate ASTM listed below or as modified herein.

1) ASTM C-700, Standard Specification for "Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.

2) ASTM C-425, Standard Specification for "Compression Joints for Vitrified Clay Pipe and Fittings."

3) ASTM C-12, Standard practice for "Installing Vitrified Clay Pipelines."

Minimum laying lengths shall not be less than five and one-half (5 ½') feet for pipes twelve (12") inches and smaller, and seven and one-half (7 ½') feet for pipes fifteen (15") inches and larger in diameter.

Pre-fabricated joints shall be of a type where the same resilient material is used both on the spigot end and the bell end of the pipe. Other type joints may be approved by the Engineer in writing, and shall similarly conform to the requirements of said ASTM C-425.

B) **Maximum Depth of Cover** - The maximum depth of cover above top of the pipe shall not exceed the value shown in the table below. The maximum depth of cover for each pipe size is based on AASHTO HS-20 live loading, ordinary clay backfill with kμ' of 0.130 and a unit weight of one hundred twenty (120 pcf) pounds per cubic foot, a design load safety factor of 1.30, Class "B" Bedding Installation, the maximum trench width specified in Section 212, and the minimum required three-edge bearing strength, for each pipe size as specified in ASTM C-700.

TABLE 649.04.01 – Maximum Depth of Cover

Nominal Size (inches)	Minimum Three-Edge Bearing Strength (lb/ft)	Maximum Depth of Cover (feet)
4	2000	25
6	2000	25
8	2200	20
10	2400	18
12	2600	16
15	2900	15
18	3300	14
21	3850	14
24	4400	14
27	4700	13
30	5000	13
33	5500	13
36	6000	13
39	6500	13
42	7000	12

649.04.02 – TRENCHLESS CONSTRUCTION

A) General - All VCP and fittings shall conform to the requirements of ASTM C-1208.

B) Sliplining Installations - Pipes used for sliplining installations shall meet the following requirements:

1) For existing pipes with a nominal inside diameter (I.D.) less then or equal to thirty-three (33”) inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than three (3”) inches smaller than the nominal I.D. of the existing pipe.

2) For existing pipes with a nominal I.D. greater than thirty-three (33”) inches, the O.D. of the sliplining pipe shall not be more than six (6”) inches smaller than the nominal I.D. of the existing pipe.

3) In addition, the maximum outside diameter, and wall thickness of VCP liner pipe shall be as follows:

Existing Sewer Line Nominal Inside Dia. (inches)	Maximum Outside Diameter of VCP (inches)	Minimum VCP Wall Thickness (inches)
12	10.50	1.31
15	14.17	2.17
18	15.60	1.75
21	15.60	1.75
24	20.70	2.50
27	24.55	2.43
30	28.60	2.80
33	31.03	2.86
36	33.46	2.95
42	37.80	3.15

649.06 – 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.

649.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

VITRIFIED CLAY SEWER PIPE (VCP)(SIZE) L.F.

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.

SECTION 650 – DUCTILE IRON PIPE (DIP)

650.01 – 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 four (4) to sixty-four (64) inches in diameter.

650.02 – MATERIALS

650.02.01 – 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.

A) Type "A" Certification for pipe
B) Type "D" Certification for elastomeric gasket
C) Shop drawings of the pipe and joints
D) Documentation of an ongoing manufacturer's quality control program

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.

The Contractor shall submit six (6) copies of all submittals requested in this specification.

650.02.02 – GENERAL, FITTINGS

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

A) ASTM A-746, Standard Specifications for Ductile Iron Gravity Sewer Pipe

B) B) AWWA C-111/ANSI A21.11, Rubber Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings

C) AWWA C-150/ANSI A21.60, Thickness Design of Ductile-Iron Pipe

D) AWWA C-151/ANSI A21.61, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lines Molds, for Water or Other Liquids

E) AWWA C-600, Installation of Ductile Iron Water Mains and Their Appurtenances

Pipe shall be provided on nominal lengths of twenty (20') feet. Pipe joints shall be push-on joints and comply with all applicable requirements of AWWA C-111/ANSI A21.11.

650.02.03 – COATING AND LINING

A) **Exterior Coating** - The exterior of ductile iron pipe, specials and fittings shall be coated with an asphaltic coating in accordance with ASTM A-746, Section 6.1. The coating shall have a minimum thickness of one (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.

B) **Interior Lining** - Interior surfaces of pipe and fittings shall be lined with forty (40) mils of Virgin Polyethylene complying with ASTM D-1248 or Madison Polyurethane Lining, Corropipe II TX-5 Minute Number 17115, manufactured by Madison Chemicals, Inc., Canada, or an approved equal. The lining materials shall be compounded with a minimum of two (2%) percent carbon black to resist ultra violet rays.

650.02.04 – 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.

TABLE 650.02.01 – Minimum Pipe Design - DIP

Pipe Nominal Size (inches)	Depth of Cover (feet)									
	? 10'		> 10' or ? 15'		> 15' or ? 20'		> 20' or ? 25'		> 25' or ? 30'	
	Nominal Thickness (inches)	Standard Pressure Class AWWA C-151	Nominal Thickness (inches)	Standard Pressure Class AWWA C-151	Nominal Thickness (inches)	Standard Pressure Class AWWA C-151	Nominal Thickness (inches)	Standard Pressure Class AWWA C-151	Nominal Thickness (inches)	Standard Pressure Class AWWA C-151
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

650.06 – 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.

650.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

DUCTILE IRON PIPE (DIP)(SIZE) L.F.

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.

SECTION 651 – HIGH DENSITY POLYETHYLENE (HDPE) PIPE

651.01 – DESCRIPTION

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

651.02 – MATERIALS

651.02.01 – SUBMITTALS

Submittals shall be furnished in accordance with Section 650.02.

651.02.02 – 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 D-1248 and with an established hydrostatic design basis (HDB) of not less than sixteen hundred (1,600) pounds per square inch for water at 73.4° F determined in accordance with ASTM Test Method D-2837. 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 D-3350, and as shown below.

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 two (2) years of storage life and meets the requirements established below at the time of installation.

Property	ASTM Test Method	Minimum Value
Density	D-1505	0.941 (gm/cm^3)
Melt Index	D-1238	< 0.15 (gm/10 min.)
Initial Flexural Modulus	D-790	110,000 psi
Long-Term Flexural Modulus	*	28,200 psi
Initial Flexural Strength	D-790	3,000 psi
Long-Term Flexural Strength	*	1,500 psi
Environmental Stress Crack Resistance, Test Condition C, (failure % = hours)	D-1693	F_{20} = 192
Hydrostatic Design Basis	D-2837	1,500 psi
Color & Ultraviolet Stabilizer	D-3350	Black with minimum 2% carbon black

* Note: The long-term values are considered to be for a continuous load duration of fifty (50) years for design loading conditions and shall be certified by the manufacturer.

651.02.03 – SOLID WALL (HDPE)

A) **General** - All solid wall HDPE pipes may be used for open-cut and sliplining installations, in sizes ranging from six (6") inches to forty-eight (48") inches in diameter. All solid wall HDPE pipe and fittings shall be manufactured in accordance with ASTM F-714.

B) **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. Butt fusion procedures shall be qualified in accordance with Title 49 Code of Federal Register, Part 192.283 and personnel qualified in accordance with 49 CFR 192.285.

Pipe Stiffness - For all open-cut installations, HDPE pipe shall have a minimum pipe stiffness of forty-six (46 psi) pounds per square inch as determined in accordance with ASTM D-2412.

651.02.04 – PROFILE WALL (HDPE)

A) **General** - All open or closed profile wall HDPE pipe and fittings may be manufactured in accordance with ASTM F-894. Pipes shall be supplied in sizes from eighteen (18”) inches to one hundred and twenty (120”) 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.

B) **Pipe Stiffness** - For all installations specified, HDPE pipe and fittings shall have a minimum pipe stiffness of forty-six (46 psi) pounds per square inch as determined in accordance with ASTM D-2412.

C) **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 D-3212.

D) **Gaskets** - Gaskets shall meet the requirements of ASTM F-477 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.

E) **Lubricant** - The lubricant used for assembly shall have no detrimental effect on the gasket or on the pipe. Type and application of the lubricant shall be in accordance with the manufacturer's recommendations.

651.04 – CONSTRUCTION METHODS

651.04.01 - SLIPLINING

A) **General -** Pipes used for sliplining installations shall meet the following requirements:

1) For existing pipes with a nominal inside diameter (I.D.) less then or equal to thirty-three (= 33”) inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than three (> 3”) inches smaller than the nominal I.D. of the existing pipe.

2) For existing pipes with a nominal I.D. greater than thirty-three (> 33”) inches, the O.D. of the sliplining pipe shall not be more than six (6”) inches smaller than the nominal I.D. of the existing pipe.

3) In addition, sliplining pipes shall meet the requirements outlined in parts B or C as applicable.

B) **Solid Wall HDPE Pipes**

1) **General** - Solid Wall HDPE Pipes shall meet the requirements of Section 651.02 Parts “A” and “B”.

2) **SDR -** 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

3) **Outside Diameter** - 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
54	48.000

C**) Profile Wall HDPE Pipes -** Profile wall HDPE pipe shall meet the requirements of Section 651.02.04 Parts “A” through “E”.

651.04.02 – PIPE BURSTING, BORING, AND TUNNELING

The HDPE pipe used for these installations shall meet the material requirements of Section 651 and meet the SDR requirements of Section 651.04.01 Paragraph B 2. and have a minimum inside diameter equal to nominal pipe size. Outside diameter requirements of Section 651.04.01 Paragraph B 3 are not applicable.

651.06 – 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.

651.07 – 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) L.F.

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.

SECTION 652 – POLYVINYL CHLORIDE (PVC) PIPE

652.01 – DESCRIPTION

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

652.02 – MATERIALS

652.02.01 – SUBMITTALS

Submittals shall be furnished in accordance with Section 650.02.

652.02.02 – 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.

A) **ASTM D-3034** - Standard Specification for "Type PSM Poly (Vinyl Chloride) (VC) Sewer Pipe and Fittings". Pipe and fittings shall have a minimum stiffness of forty-six (46 psi) pounds per square inch and a minimum SDR of thirty-five (35). Pipe and fittings may be supplied in sizes ranging from four (4”) inches to fifteen (15”) inches in diameter.

The pipe shall be made of PVC plastic having a cell classification of 12454-B or 12454-C or 12364-C or 13364-B (with minimum tensile modulus of 500,000 psi) as defined in ASTM D-1784. The fittings shall be made of PVC plastic having a cell classification of 12454-B, 12454-C, or 13343-C as defined in ASTM D-1784.

Elastomeric Gasketed Joints shall be used to provide a watertight seal and shall meet the requirements of ASTM D-3212.

B) **ASTM F-679** - Standard Specification for "Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings". Pipe and fittings shall have a minimum stiffness of forty-six (46 psi) pounds per square inch and a minimum SDR of thirty-five (35). Pipe and fittings may be supplied in sizes ranging from eighteen (18”) inches to thirty-six (36”) inches in diameter.

The pipe and fitting materials shall be made of PVC plastic having a minimum cell classification of 12364-C or 12454-C as defined in ASTM D-1784. Homopolymer PVC compounds must equal or exceed the requirements of the above listed minimum cell classification number.

Integral Bell Gasket Joint shall be used to provide a watertight seal and shall meet the requirements of ASTM D-3212.

C) **ASTM F-789** - Standard Specification for "Type PS-46 Poly (Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings". Pipe and fittings shall have a minimum stiffness of forty-six (46 psi) pounds per square inch. Pipe and fittings may be supplied in sizes ranging from four (4”) inches to eighteen (18”) inches in diameter.

The pipe shall be made of PVC plastic having a minimum cell classification of 12164-B as defined in ASTM D-1784. The fittings shall be made of PVC plastic having a cell classification of 12454-C or 13343-C as defined in ASTM D-1784.

Elastomeric Gasketed Joints shall be used to provide a watertight seal and shall meet the requirements of ASTM D-3212. Joints shall also be compatible to ASTM D-3034 joint dimensions.

652.02.03 – PROFILE WALL (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.

A) ASTM F-794 - 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 forty-six (46 psi) pounds per square inch. Pipe and fittings may be supplied in sizes ranging from twelve (12”) inches to forty-eight (48”) inches in diameter.

The pipe and fittings shall be made of PVC plastic having a minimum cell classification of 12454-B or 12364-C as defined in ASTM D-1784.

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 D-3212.

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 D-3212.

B) ASTM F-949 - 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 fifty (50 psi) pounds per square inch. Pipe and fittings may be supplied in sizes ranging from twelve (12”) inches to thirty-six (36”) inches in diameter.

The pipe shall be made of PVC plastic having a minimum cell classification 12454-B or 12454-C as defined in ASTM D-1784. The fittings shall be made of PVC plastic having a cell classification of 12464-B, 12464-C, or 13343-C as defined in ASTM D-1784.

Elastomeric Gasketed Joints shall be used to provide watertight seal and shall meet the requirements of ASTM D-3212.

652.02.04 – SPECIAL PVC PIPE

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

A) ASTM D-2241 - Standard Specifications for Polyvinyl Chloride (PVC) Pressure-rated Pipe (SDR Series). Pipe and fittings shall have a minimum SDR of thirty-two and one-half (32 1/2) and may be supplied in sizes ranging from four (4) inches to thirty-six (36) inches in diameter.

The pipe and fittings shall be made of PVC compounds having a cell classification of 12454-B, 12454-C, or 14333-D as defined in ASTM D-1784.

Elastomeric gasketed joints meeting the requirements of ASTM D-3212 shall be used to provide a watertight seal.

B) AWWA C-900 and AWWA C-905 - Standards for PVC Pressure Pipe from four (4”) inches through twelve (12”) inches, and fourteen (14”) inches through thirty-six (36”) inches, respectively. Pipes shall have a minimum DR rating of eighteen (18) for diameters four (4”) inches through twelve (12”) inches. For pipes greater than twelve (12”) inches in diameter, the minimum DR shall be thirty-two and one-half (32 1/2).

The pipe and fittings shall be made of PVC compounds having a cell classification of 12454-A or 12454-B as defined in ASTM D-1784.

Elastomeric gasketed joints meeting the requirements of ASTM D-3139, when measured in accordance with ASTM-2122, shall be used to provide a watertight seal.

652.02.05 – GASKETS AND LUBRICANTS

Gaskets and lubricants shall conform to the requirements of Section 651.02.03 Parts “D” and “E”.

652.02.06 – CHEMICAL RESISTANCE

All PVC pipe and fittings shall have demonstrated a resistance to damage when subjected to exposure and/or contact with liquid sewage and/or gasses associated with sewage and/or high hydrogen sulfide concentration.

652.04 – CONSTRUCTION METHODS

A) Open-Cut - PVC pipe and fittings shall meet the requirements of Section 652.02 through 652.04 as applicable.

B) Pipe Bursting - PVC pipe and fittings shall conform to the requirements of Section 652.04.

C) Jacking - PVC pipe and fittings shall conform to the requirements of Section 652.04.

D) Boring and Tunneling - PVC pipe and fittings shall meet the requirements of Section 652.02 and 652.03.

E) Micro or Small Diameter Tunneling - PVC pipe and fittings shall meet the requirements of Section 652.02 and 652.03, Part “A” and joint requirements specified in Part “F” of this subsection.

Sliplining –

General - 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 D-3212. PVC pipe shall meet the material requirements specified in Section 652.02 and 652.03. 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 thirty-three (33) inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than three (3) inches smaller than the nominal I.D. of the existing pipe.

For existing pipes with a nominal I.D. greater than thirty-three (33) inches, the O.D. of the sliplining pipe shall not be more than six (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	

652.06 – 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.

652.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

POLYVINYL CHLORIDE (PVC) (SIZE) L.F.

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.

SECTION 653 – REINFORCED FIBERGLASS PIPE (RFP)

653.01 – DESCRIPTION

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

653.02 – MATERIALS

653.02.01 – SUBMITTALS

Submittals shall be furnished in accordance with Section 650.02.

653.02.02 – GENERAL

All pipes, joints and fittings shall be manufactured in accordance with the requirements of ASTM D-3262 or as modified herein. Pipes shall be supplied in sizes twelve (12) inches and larger.

Pipes shall be centrifugally cast, fiberglass-reinforced polyester resin as manufactured by Hobas USA, Inc. or approved equal.

Prior to manufacturing, the pipe supplier shall provide the Engineer with test reports certifying that the pipe has been tested in accordance with, and exceeds all minimum requirements of ASTM D-2992, ASTM D-3262 and ASTM D-3681. Manufacturer's "in house" testing reports WILL NOT be acceptable as a substitute for independent laboratory testing.

653.02.03 – MINIMUM PIPE STIFFNESS

The pipe stiffness shall be a minimum of forty-six (46 psi) pounds per square inch when measured in

accordance with ASTM D-2412 for all installations except jacking. Other pipe stiffnesses may be used when called for on the plans or as directed by the Engineer.

653.02.04 – MATERIAL COMPONENTS

A) **Resin System** - The manufacturer shall use only approved polyester or epoxy resin 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.

B) **Glass Reinforcements** - 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.

C) **Fillers** - Sand may be used as fillers providing that sand shall be a minimum ninety-eight (98%) percent silica with a maximum moisture content of 0.2 percent.

D) **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.

E) **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 D-3681.

653.02.05 – DIMENSIONS

A) **General** - Pipe outside diameters shall be in accordance with AWWA Standards C-151 and C-950 and as shown below. The minimum wall thickness(es) shown are for a minimum pipe stiffness of forty-six (46 psi) pounds per square inch.

Nom. Pipe Dia. (inches)	Pipe O.D. (inches)	Min. Wall Thickness (inches)
12	13.20	0.30
14	15.30	0.34
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
54	57.10	1.14
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
102	108.00	2.13

Pipe shall be supplied in nominal lengths of ten (10') feet or twenty (20') feet for Jacking, and twenty (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 ten (10') feet or six and two-thirds (6 2/3") feet shall be used. Actual laying length shall be the nominal plus or minus (±) two (2") inches. Except for special order lengths, all pipes shall be furnished in the nominal lengths specified herein. All pipe ends shall be square to the pipe axis plus or minus (±) one-fourth inch (1/4"), or plus or minus (±) five-tenths (0.5%) percent of the nominal diameter (whichever is greater).

B) **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:

TABLE 653.02.01 – Jacking Installations Wall Thickness

Nom. Pipe Dia. (inches)	Pipe O.D. (inches)	Min. 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

C) **Sliplining Installations** - Pipes used for sliplining installations shall meet the following general requirements:

1) For existing pipes with a nominal inside diameter (I.D.) less than or equal to thirty-three (=33”) inches, the outside diameter (O.D.) of the sliplining pipe shall not be more than three (3”) inches smaller than the nominal I.D. of the existing pipe.

2) For existing pipes with a nominal I.D. greater than thirty-three (>33”) inches, the O.D. of the sliplining pipe shall not be more than six (6”) inches smaller than the nominal I.D. of the existing pipe.

3) In addition, sliplining pipes shall meet the following requirements:

Exist. Sewer Line Nominal Inside Diameter (inches)	RFP Liner O.D. (inches)	Wall Thickness (inches)
15	13.20	0.30
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

Exist. Sewer Line Nominal Inside Diameter (inches)	RFP Liner O.D. (inches)	Wall Thickness (inches)
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

653.02.06 - JOINTS

A) General - 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 D-4161.

B) 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.

C) 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.

653.02.07 – GASKETS AND LUBRICANTS

Gaskets and lubricants shall conform to the requirements of Section 651.02.04, Parts “D” and “E”.

653.02.08 – 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.

The tolerance of the angle of an elbow and the angle between the main and leg of a wye or tee shall be plus or minus (±) two (2°) degrees. The tolerance on the laying length of a fitting shall be plus or minus (±) two (2”) inches.

653.06 – 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.

653.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

REINFORCED FIBERGLASS PIPE (RFP) (SIZE) L.F.

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.

SECTION 654 – STEEL CASING PIPE

654.01 – 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.

654.02 – MATERIALS

654.02.01 – 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.

A) Type "A" certification for pipe and coating
B) Shop drawings of pipe, joints and seams
C) Documentation of manufacturer's on-going quality control program.

654.02.02 – GENERAL

A) General - Steel pipe shall conform to ASTM A-139, 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 sixty thousand (60,000 psi) pounds per square inch tensile strength, and minimum thirty-five thousand (35,000 psi) pounds per square inch yield strength.

The pipe shall be straight seam pipe, seamless pipe, or spiral weld pipe. For spiral weld pipe, the spiral shall be one hundred (100%) percent welded, and the weld's height over the outside wall surface shall be equal to or less than three-sixteenths (3/16”) inch. 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 one (1%) percent of the specified nominal outside diameter or one-fourth (1/4”) inch, whichever is less. The outside circumference must be within plus or minus (±) one (1%) percent of the nominal circumference or within plus or minus (±) one-half (1/2”) inch, which is less. The pipe shall have a maximum allowable straightness deviation in any ten (10’) foot length of one-eighth (1/8”) 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 C-206.

B) Boring Installations

1) Casing Pipe Size - Steel casing pipe shall have the following suggested inside diameters:

Pipe Nominal Size (inches)	Casing Pipe Inside Diameter (inches)
4	8 to 10
6	10 to 12
8	14 to 16
10	16 to 18
12	18 to 20
15	20 to 22

18	24 to 26
24	31 to 33
27	33 to 36
30	36 to 42
36	42 to 48
42	54 to 60
48	60 to 66

2) 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 HIGHWAY**		**UNDER RAILROAD**		
(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

C) Micro and Small Diameter Tunneling - The steel casing pipe minimum wall thickness for micro and small diameter tunneling shall be one-fourth (1/4") inch.

D) 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.

654.02.04 – EXTERIOR PROTECTIVE COATING

Exposed exterior surfaces shall have protective coating, shop applied coal-tar enamel, conforming to the requirements of AWWA C-203. The coating thickness shall be forty (40) mils, applied in two (2) coats.

654.06 – 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.

654.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

STEEL CASING PIPE (SIZE) L.F.

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.

SECTION 655 – DEFORMED HIGH DENSITY POLYETHYLENE PIPE

655.01 – 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.

655.02 – MATERIALS

Materials shall meet the requirements of Section 651.02 except that it shall be Class B as defined in ASTM D-1248. The minimum cell classification shall be PE 346434D, white color, as defined in ASTM D-3350.

655.02.01 – 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 design assumptions outlined in Section 617.02.03.

Pipe Nominal Size (inch)	Depth of Cover (feet)				
	? 10'	> 10' or ? 15'	> 15' or ? 20'	> 20' or ? 25'	> 25' or ? 30'
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

655.06 – 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.

655.07 – 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) L.F.

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.

SECTION 656 – FOLDED POLYVINYL CHLORIDE (PVC) PIPE

656.01 – 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.

656.02 – MATERIALS

The installed folded PVC pipe shall meet the performance requirements of ASTM D-3034. In addition, the PVC Compound used, shall conform to the properties outlined in ASTM D-1784 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

* Note: The long-term values are considered to be for a continuous load duration of fifty (50) years for design loading conditions and shall be certified by the manufacturer.

656.02.01 – 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 design assumptions outlined in Section 617.02.03.

Pipe Nominal Size (inch)	Depth of Cover (feet)				
	? 10'	> 10' or ? 15'	> 15' or ? 20'	> 20' or ? 25'	> 25' or ? 30'
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

656.06 – 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.

656.07 – 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) L.F.

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.

SECTION 657 – RESIN IMPREGNATED TUBE

657.01 – 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. Resin impregnated tube shall conform to the requirements of ASTM F-1216.

657.02 – MATERIALS

A) **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.

B) **Resin** - The resin shall be a thermoset and catalyst type, or an epoxy resin and hardener that is compatible with the inversion process.

C) **Minimum Physical Properties** - 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	D-790	4,500	4,000
Long-term Flexural Strength	*	2,250	2,000
Initial Flexural Modulus	D-790	250,000	400,000
Long-term Flexural Modulus	*	125,000	200,000

Notes:
?Materials with initial flexural modulus of 250,000 psi
+Materials with initial flexural modulus of 400,000 psi
*The long-term values are considered to be for a continuous load duration of fifty (50) years for design loading conditions and shall be certified by the manufacturer.

D) **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 preformed in accordance with Appendix X2. of ASTM F-1216 and meet all the requirements specified therein.

657.02.01 – 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, meeting the requirements stated in Section 657.02 and design assumptions outlined in Section 657.02. Should the Contractor propose a resin system that differs from Section 617.02.03, he shall submit the proposed physical properties for design and calculated minimum thickness for review and approval by the Engineer. The Engineer shall be the sole judge as to the appropriate minimum thickness to be furnished and the use of the product.

Pipe Nominal Size (inches)	Depth of Cover (feet)									
	? 10'		> 10' or ? 15'		> 15' or ? 20'		> 20' or ? 25'		> 25' or ? 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
10	0.233	0.191	0.273	0.234	0.311	0.266	0.343	0.293	0.371	0.317
12	0.280	0.229	0.328	0.280	0.373	0.319	0.411	0.352	0.445	0.380
15	0.350	0.286	0.410	0.350	0.467	0.400	0.514	0.439	0.556	0.475
18	0.420	0.344	0.491	0.420	0.560	0.479	0.617	0.627	0.667	0.670
21	0.490	0.401	0.673	0.490	0.653	0.558	0.719	0.615	0.777	0.665
24	0.560	0.458	0.655	0.560	0.746	0.888	0.822	0.703	0.889	0.760
27	0.630	0.515	0.736	0.630	0.839	0.718	0.925	0.791	1.000	0.855
30	0.700	0.573	0.818	0.700	0.933	0.798	1.027	0.879	1.111	0.960
33	0.770	0.630	0.900	0.770	1.026	0.877	1.130	0.966	1.222	1.045
36	0.840	0.687	0.982	0.840	1.119	0.957	1.233	1.054	1.333	1.140
42	0.980	0.801	1.145	0.980	1.306	1.117	1.438	1.230	1.655	1.330
48	1.120	0.916	1.309	1.119	1.492	1.276	1.644	1.406	1.777	1.520
54	1.260	1.030	1.473	1.259	1.679	1.436	1.849	1.581	2.000	1.710
60	1.400	1.145	1.636	1.400	1.865	1.595	2.054	1.757	2.221	1.900
66	1.540	1.260	1.800	1.540	2.052	1.754	2.260	1.932	2.443	2.100
72	1.680	1.373	1.963	1.679	2.238	1.914	2.465	2.108	2.665	2.280
78	1.820	1.490	2.127	1.819	2.423	2.073	2.671	2.284	2.888	2.470
84	1.960	1.602	2.291	1.959	2.611	2.233	2.876	2.459	3.110	2.660
90	2.100	1.717	2.454	2.100	2.798	2.392	3.082	2.635	3.332	2.850
96	2.240	1.831	2.618	2.239	2.984	2.552	3.284	2.811	3.554	3.040

Notes:
?Materials with initial flexural modulus of 250,000 psi
+Materials with initial flexural modulus of 400,000 psi

657.06 – 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.

657.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

RESIN IMPREGNATED TUBE (SIZE) L.F.

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.

SECTION 658 – SPECIAL SANITARY SEWER PIPE

658.01 – GENERAL

This section covers installation of sewer pipes, as specified herein, at locations called for on the plans, as required to satisfy minimum horizontal and vertical clearance requirements, from waterline, wells, and petroleum storage tanks, as established by the Oklahoma Department of Environmental Quality (DEQ).

658.02 – PIPE MATERIALS

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

Pipe Type	Pipe Material	Section
Flexible	Ductile-Iron Pipe (DIP)	650
	Polyvinyl Chloride (PVC) Pipe	652

658.04 – CONSTRUCTION METHODS

Pipe installation shall be in accordance with the requirements and in conformance with the applicable sections of these specifications. If joining dissimilar pipe materials, concrete collars, as per "Standard Detail for Pipe Encasement and Collar", shall be used.

658.06 – METHOD OF MEASUREMENT

Payment for "Special Sanitary Sewer Pipe" shall be made at the unit price bid per lineal foot installed for each size. The price established shall be full compensation for all materials including pipe, concrete collars when necessary, 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 and embedment materials.

"Special Sanitary Sewer Pipe" shall be measured along the pipe, through manhole, junction boxes and other small structures.

658.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

SPECIAL SANITARY SEWER PIPE (SIZE) L.F.

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.

SECTION 659 - PIPE ENCASEMENT AND COLLAR

659.01 - DESCRIPTION

This section covers protection of sewer lines by concrete pipe encasement and collar where called for on the plans, or as directed by the Engineer.

659.04 - CONSTRUCTION REQUIREMENTS

A) **General** - Pipe encasement and collar shall be constructed in accordance with the "Standard Detail for Pipe Encasement and Collar".

B) **Pipe Encasement** - Pipe encasement shall be placed to the limits shown on the plans.

C) **Collar** - Collar shall be concrete encasement placed to a minimum twelve (12") inches on either side of the joint.

659.06 – METHOD OF MEASUREMENT

Payment for "Pipe Encasement" and "Collar" shall be made at the unit price bid per cubic yard of concrete. The price established shall be full compensation for labor, materials, including concrete, tools, equipment, and incidentals necessary to complete this item of work.

SECTION 660 – AERIAL CROSSING

660.01 – DESCRIPTION

This section covers construction of aerial sewer crossing as shown on the plans. Each crossing involves excavation and backfill, construction of reinforced concrete bases and piers, carrier pipe, sewer pipe, and all incidental work.

660.02 – MATERIALS

A) **Sewer Pipes** - All pipes shall conform to the requirements of Section 610.

B) **Carrier Pipe** - Acceptable carrier pipe material shall meet the requirements of the appropriate section listed below:

Carrier Pipe Material	Section
Steel Casing Pipe	654.02

C) **Formed Reinforced Concrete**

Unless otherwise specified, all concrete used in construction of sanitary sewers and their appurtenances shall have a minimum twenty-eight (28) day compressive strength of thirty-five hundred (3,500 psi) pounds per square inch. All steel reinforcement used shall be grade sixty (60) with a minimum yield strength of sixty (60,000 psi) pounds per square inch.

660.04 – CONSTRUCTION METHODS

A) **General** - Construction of aerial crossing shall be as called for on the plans and in accordance with the "Standard Detail for Aerial Crossing".

B) **Skid Supports** - Skid supports shall comply with the requirements of Section 252.04, Part “C”.

C) **Plugging Pipe Ends** - Plugging Pipe Ends shall comply with the requirement of Section 252.04, Part “D”.

660.06 – METHOD OF MEASUREMENT

A) 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 carrier pipe, sanitary sewer pipe, skid support, plugging pipe, tie-down straps, anchor bolts, and all tools, labor, equipment, and incidentals necessary to complete this item of work.

B) Payment for Concrete Collar with Spread Footing” shall be made at the unit price bid per each. The price established shall be full compensation for excavation and backfill, compacted rock foundation, materials including reinforced concrete for footing and collar, labor, tools, equipment, and incidentals necessary to complete this item of work.

C) Payment for "Pier" shall be made at the unit price bid per vertical foot for each pier shaft for either Type I or Type II. The price established shall be full compensation for excavation materials, including reinforced concrete for piers, labor, tools, equipment, and incidentals necessary to complete this item of work. Measurement for payment shall be made from the top of the collar to the bottom of the pier.

660.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

AERIAL CROSSING (SIZE)	L.F.
FOOTING	EA.
PIERS (TYPE)	V.F.

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.

SECTION 690 – SANITARY SEWER CONSTRUCTION STANDARD BID ITEMS

690.01 – 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.

SECTION	DESCRIPTION	UNIT
611	SEWER SERVICE CONNECTION	EA.
611	RISER PIPE	L.F.
612	SEWER SERVICE LINE	L.F.
613	PLUGGING ABANDONED SEWER	EA.
614	ABANDONING SEWER/ABANDONING MANHOLE	C.Y.
615	PIPE BURSTING (SIZE)	L.F.
616	SLIPLINING (SIZE)	L.F.
617	FORMED-IN-PLACE PIPE (SIZE)	L.F.
618	SEWER FLOW CONTROL	L.S.
619	CLEANING SEWER LINE	L.F.
620	SMOKE TESTING	L.F.
622	POINT REPAIR	EA.
623	DEFLECTION TEST (SIZE)	L.S.
623	DEFLECTION TEST (SIZE)	L.F.
624	TELEVISION INSPECTION	STA.
624	TELEVISION INSPECTION (CCTV)	L.F.
625	SEWER LEAK TEST (SIZE)	L.S.
625	SEWER LEAK TEST (SIZE)	L.F.
626	SANITARY SEWER MANHOLE	EA.
626	EXTRA DEPTH MANHOLE WALL(SIZE)	V.F.
627	MANHOLE TESTING	EA.
628	SANITARY SEWER MANHOLE REHABILITATION	V.F.
630	MANHOLE WATERPROOFING	EA.
631	MANHOLE JOINT WATERPROOFING	EA.
632	MANHOLE RING WATERPROOFING	EA.
633	MANHOLE COVER WATERPROOFING	EA.
635	INVERT AND BENCH RECONSTRUCTION	EA.
647	REINFORCED CONCRETE PIPE (SIZE)	L.F.
649	VITRIFIED CLAY SEWER PIPE (VCP)(SIZE)	L.F.
650	DUCTILE IRON PIPE (DIP)(SIZE)	L.F.
651	HIGH DENSITY POLYETHYLENE (HDPE) PIPE (SIZE)	L.F.
652	POLYVINYL CHLORIDE (PVC) (SIZE)	L.F.
653	REINFORCED FIBERGLASS PIPE (RFP) (SIZE)	L.F.
654	STEEL CASING PIPE (SIZE)	L.F.
655	DEFORMED HIGH DENSITY POLYETHYLENE PIPE (SIZE)	L.F.
656	FOLDED POLYVINYL CHLORIDE (PVC) PIPE (SIZE)	L.F.
657	RESIN IMPREGNATED TUBE (SIZE)	L.F.
658	SPECIAL SANITARY SEWER PIPE (SIZE)	L.F.
660	AERIAL CROSSING (SIZE)	L.F.
660	FOOTING	EA.

SECTION	DESCRIPTION	UNIT
660	PIERS	V.F.
610	SANITARY SEWER PIPE (SIZE)	L.F.