

SECTION 17 - SANITARY SEWER PIPE AND APPURTENANCES

17-1 GENERAL

Sewer pipe, manholes, stub-outs, house branches, and service laterals shall be furnished in accordance with the requirements established in these specifications. Also included is the testing and internal inspection of all sewer lines.

No public sewer may be smaller than eight inches (8") in diameter.

17-2 MATERIALS

Sewer pipe and fittings shall be vitrified clay, unplasticized polyvinyl chloride (PVC), or PVC lined reinforced concrete pipe, as specified herein.

17-2.1 Vitrified Clay Pipe (VCP)

17-2.1.1 General

Vitrified clay sewer pipe for sanitary sewers and house connection sewers shall conform to the following requirements.

17-2.1.2 Manufacturing Requirements

Vitrified clay pipe shall be mechanical compression joint pipe, Band Seal, Wedge Lock, Speed Seal or approved equal. Vitrified clay pipe and fittings shall be extra strength, first quality, sound and well burned throughout their entire thickness and shall comply with the current revisions of ASTM Designation C-700.

17-2.1.3 Installation

Pipe shall be installed in accordance with the current revisions of ASTM Practice C-12.

17-2.1.4 Testing

Pipe shall be tested in accordance with the current revisions of ASTM Method C-301.

17-2.2 Polyvinyl Chloride (PVC) Pipe

17-2.2.1 General

Polyvinyl Chloride (PVC) sewer pipe for sanitary sewers and house connection sewers shall conform to the following requirements:

Pipe Size (inches)	A.S.T.M. Min.	Min. Wall Thickness
4-15	D 3034	SDR35
18-30	F 679	PS46
18-60	F 1803	PS46

17-2.2.2 Manufacturing Requirements

1. Identification Marks

All pipe, fittings, and couplings shall be clearly marked at intervals not to exceed 5 feet as follows:

- a. Nominal pipe diameter
- b. PVC cell classification
- c. Company, plant, shift, ASTM, SDR or pipe stiffness, and date designation

For fittings and couplings, the SDR designation is not required.

2. Cell Classification

PVC pipe shall be made of PVC compound having a cell classification of 12454- B, 13364-A, or 13364-B conforming to ASTM D 1784. The fittings shall be made of PVC compound having a cell classification of 12454-B, 12454-C, or 13343-C. Additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed 10 parts by weight per 100 of PVC resin in the compound.

17-2.2.3 Joining Systems

A. General

All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made. The socket and spigot configurations for the fittings and couplings shall be compatible to those used for the pipe.

B. Elastomeric Gasket Joints

Pipe shall be manufactured with a socket configuration which will prevent improper installation of the gasket and will ensure that the gasket remains in place during the joining operation.

PVC pipe shall be joined with rubber gaskets. Rubber gaskets shall be manufactured from a synthetic elastomer and shall comply in all respects with the physical

requirements specified in ASTM F 477. The compound shall contain not less than 50% by volume of first-grade rubber. The remainder of the compound shall consist of pulverized fillers free of rubber substitutes, reclaimed rubber, and deleterious substances. The Contractor shall retest within 60 days prior to installation, any pipe gasket that is more than 180 days old from the date of manufacture to ensure compliance with the requirements of the Specifications.

The Contractor shall not install any pipe gasket that is more than 2 years old from the date manufacture.

Gaskets shall be extruded or molded and cured in such a manner as to be dense, homogenous and of smooth surface, free of pitting, blisters, porosity and other imperfections. The tolerance for any diameter measured at any cross section shall be $\pm 1/32$ inch.

When required by the Engineer, the Contractor shall furnish test samples of gaskets from each batch used in the Work. Gasket material shall meet the following requirements:

Property	Value	ASTM Test Method
Tensile strength, psi min.	1500	D 412
Elongation at break (% min.)	350	D 412
Shore durometer, Type A Pipe manufacturer shall select value suitable for type of joint)	40 to 65'	D 2240
Compression set (constant deflection) max. % of original deflection	16	D 395 Method B
Tensile strength after oven aging (96 hours, 158 deg. F) % of tensile strength before aging	80	D 573
Increase in shore durometer hardness after over aging. Maximum increase over original Shore durometer	10	D 2240
Physical requirements after exposure to ozone concentration (150 pphm. 70 hours, 104 deg. F, 20% strain)	No Cracks	D 1149

No more than one splice will be permitted in a gasket. A splice shall be made by applying a suitable cement to the ends and vulcanizing the splice in a full mold. The splice shall show no separation when subjected to the following tests:

1. Elongation Test

The part of the gasket which includes the splice shall withstand 100 percent elongation with no visible separation of the splice. While in the stretched position, the gasket shall be rotated in the spliced area minimum of 180° in each direction in order to inspect for separation.

2. Bend Test

The portion of the unstretched gasket containing the splice shall be wrapped a minimum of 180° and maximum of 270° around a rod of a diameter equal to the cross section diameter of the gasket.

Solvent cements are not allowed for joining pipe.

17-2.2.4 Test Requirements

1. General

Pipe, fittings, and couplings shall meet the requirements of the section entitled "Requirements" of ASTM D 3033, D 3034, F 679 ("T-1" wall only). During production of the pipe, the manufacture shall perform the specified tests for each pipe marking. A certification by the manufacture indicating compliance with the specification requirements shall be delivered with the pipe. The certification shall include the test result data. The PVC compound shall also meet the chemical resistance requirements of 17-2.2.4 D.

2. Acceptance

The basis for acceptance will be the inspection of pipe, fittings, and couplings; the tests specified in subsection 17-2.2.04 A; and compliance with the Specifications. When the pipe is delivered to the Work site, the Engineer may require additional testing to determine conformance with the requirements of pipe flattening, impact resistance, pipe stiffness, and extrusion quality.

Installation time shall conform to subsection 17-2.2.4 E.

3. Selection of Test Pipe

When testing is required by the Engineer, one test pipe shall be selected at random by the Engineer from each 1200 feet or fraction thereof of one test pipe per lot. A lot shall be defined as pipe having the same identification marking. The length of specimen for each selected pipe shall be a minimum of eight feet (8').

4. Chemical Resistance And Physical Testing

The Engineer may at any time direct the manufacturer to obtain compound samples and prepare test specimens in accordance with ASTM D 1987. These specimens shall comply with the minimum property values shown below and also with the applicable ASTM requirements.

Property	ASTM Test Method	Value (Initial and After 112-Days Exposure)
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		Cell Class 12454	Cell Class 13343	Cell Class 13364
Minimum Yield Strength (psi)	D 638	7,000	6,000	6,000
Impact Strength (Ft.-lbs/in.) Notch min.	D 256 Method A (Size 1/2" x 1/8" x 2-1/2")	0.65	1.5	1.5
Weight Change %	D 543			
Unconditioned		±1.5 Max	±1.5 Max	±1.5 Max
Conditioned		±1.0 Min	±1.0 Min	±1.0 Min

Tensile and impact exposure specimens shall be immersed in the following solutions for a period of 112 days. At 28-day intervals, selected specimens shall be removed, washed, surfaced dried, and tested.

Chemical Solution	Concentration
Sulphuric Acid (H ₂ SO ₄)	20% ¹
Sodium Hydroxide (NaOH)	5%
Ammonium Hydroxide (NH ₄ OH)	5% ¹
Nitric Acid (HNO ₃)	1% ¹
Ferric Chloride (FeCl ₃)	1%
Sodium Hypochlorite	1%
Soap	0.1%
Detergent (Linear alkyl benzyl sulfonate or LAS)	0.1%
Bacteriological	BOD not less than 700 ppm

¹ Volumetric percentages of concentrated reagents of C.P. grade. Weight change specimens shall be 2 inches in diameter and may be molded discs or discs cut from the pipe wall. They shall be conditioned in a mechanical convection oven for 7 days at 110_F ± 4_F, then cooled in a desiccator for 3 hours at 73_ ± 4_F, weighed, and then immersed in the above solutions. At 28-day intervals selected specimens shall be removed, washed, surface dried and weighed. These same specimens shall be reconditioned in a mechanical convection oven for 7 days at 110_ ± 4_F, then cooled in a desiccator for 3 hours at 73_F ± 4_F and weighed again. If any specimen fails to meet these requirements at any time, the material will be rejected.

5. Installation Time Limit

The Contractor shall retest within 60 days prior to the installation of all pipe and fittings that are more than 180 days old from the date of manufacture to ensure

compliance with the requirements of the Specifications. The Contractor shall not install any pipe that is more than 2 years old from the date of manufacture

17-2.3 PVC - Lined Reinforced Concrete Pipe

17-2.3.1 General

These specifications shall apply to reinforced concrete pipe manufactured with a plastic lining for use in sanitary sewers.

All reinforced concrete pipe used for sanitary sewers shall be 3600 PVC T-lock lined. The size, type, and D-load of the concrete pipe to be furnished shall be as shown on the plans, or as specified under the item of Work for the project of which the pipe is a part and shall be for pipe installed by open-cut method of construction.

17-2.3.2 Manufacturing Requirements

Reinforced concrete pipe shall be manufactured and tested in conformance with the requirements of ASTM C-76, except as modified herein and to the "D" load, class and size as shown on the plans with the following addition: the joints shall be O-ring rubber gasket type, the gasket will be enclosed on all four surfaces in an annular space formed by shoulders on the bell end spigot or in a groove on the spigot. The pipe shall be self-centering and the gasket or gaskets shall not be required to support the weight of the pipe.

Portland cement shall comply with ASTM C-150, Type II, low alkali.

17-2.4 Ductile Iron Pipe

Sewer pipe of ductile iron shall comply with ASTM A746 (Standard Specification For Ductile Iron Gravity Sewer Pipe) and shall be used only in special locations shown on the Plans or as specified in the Special Conditions.

17-2.5 Prohibited Pipe Materials

The following pipe materials are not allowed for use in the construction of sanitary sewers:

1. Asbestos Cement Pipe
2. High Density Polyethylene
3. (HDPE) High Density Polyethylene Plastic Pipe
4. (PE) Polyethylene Solid Wall Pipe
5. Concrete Truss Pipe
6. Cement or Mortar Lined Ductile Iron Pipe
7. Concrete Pipe (unlined or nonreinforced)

17-3 TRENCH, STRUCTURE EXCAVATION AND BACKFILL

17-3.1 General

This Work shall consist of all excavation and backfill necessary for the construction of pipelines, structures and other facilities, and the restoration of surfaces disturbed by

such Work, all as set forth in the Plans and Specifications and as directed by the Engineer.

Excavations for appurtenance structures, such as manholes, transition structures, junction structures, vaults, etc., shall be deemed to be in the category of trench excavation.

17-3.2 Trench and Structure Excavation

Excavations shall be made to the depths and widths required for construction of conduits and structures to specified dimensions and to the lines and grades indicated on the Plans. Unless otherwise indicated on the Plans, excavations for pipe construction may be open cut.

The Contractor shall be responsible for locating and protecting subsurface obstructions in the field, and shall notify the Engineer immediately if conflicts occur. Reference is made to Section 5, "UTILITIES", of these Specifications relative to existing utilities, and the protection thereof. The location of subsurface obstructions found in the field may necessitate a variance in the depth or alignment of proposed facilities.

The Contractor shall perform all excavations in accordance with the Trench Construction Safety Orders issued by the Division of Industrial Safety of the Department of Industrial Relations of the State of California.

When a trench or structure site is to be located in an existing oiled earth or pavement area, the existing surfacing to be removed shall be cut by methods approved by the Engineer along neat lines on each side of the trench or around the structure site.

Existing surfacing, when removed, shall be kept separated from the material that is to be returned to the excavation. Failure to comply with this requirement shall be grounds for rejection of the contained material for use as backfill.

Material excavated from the trench shall be placed so as to offer minimum obstructions to traffic.

All existing gas pipes, water pipes, conduits, sewers, drains, fire hydrants, and other structures which are not, in the opinion of the Engineer, required to be changed in location shall be carefully supported and protected from injury by the Contractor; and in case of injury, they shall be restored by him, without additional compensation, to as good a condition as that in which they were found.

The Contractor shall provide, without additional compensation, suitable temporary channels for the water that may flow along or across the site of the Work when necessary.

If all excavated material cannot be stored on the roadway in such a manner as to maintain access to property along side of the Work, the surplus material shall be removed from the Work and stored until needed for backfill at which time it shall be brought back. If the surplus material is to be stored on other than private property, prior approval must be obtained from the Engineer for the site to be used. The cost of removing and returning material shall be at the Contractor's expense.

17-3.2.1 Trench Widths

Trenches shall conform to the dimensions in Table 17-3.1, unless otherwise specified in the special provision, indicated on the plans, and as may be approved by the Engineer.

TABLE 17-3.1		
TRENCH WIDTHS		
Size Of Pipe (I.D.)	Maximum Width At Top Of Pipe Greater Than O.D. Of Barrel	Minimum Width At Springline Each side Of Pipe
Less than 18"	24"	6"
18" to 24" inclusive	30"	8"
27" to 39" inclusive	36"	9"
42" to 60" inclusive	Pipe O.D.	12"
Over 60"	requires design by the Project Civil Engineer	

The width of the trench shall not be greater than the maximum indicated in Table 17-3.1, at and below the level of the top of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing, and for proper installation of the Work.

If the maximum trench width as specified in Table 17-3.1 is exceeded at the top of the pipe the Contractor shall provide, at no additional cost to the City, the necessary additional load bearing capacity by means of bedding, having a higher bedding factor than that specified, higher strength pipe, a concrete cradle, cap or encasement, or by other means approved in writing by the Engineer.

17-3.2.2 Trench Grade

Alignment and elevation stakes shall be furnished to the Contractor at set intervals and agreed upon offsets. Where elevation stakes are furnished, the Engineer will also furnish the Contractor with cut sheets.

For all pipe 12 inches or greater in diameter, the Contractor shall excavate for and provide an initial granular bedding at least 4 inches thick or 1/12 the O.D. of the pipe whichever is greater. This bedding material shall be placed at a uniform density with minimum compaction and fine graded as specified below.

Bell or coupling holes shall be dug after the trench bottom has been graded. Such holes shall be of sufficient width to provide ample room for caulking, banding, or bolting. Holes shall be excavated only as necessary to permit accurate Work in the making of the joints

and to insure that the pipe will rest upon the prepared bottom of the trench, and not be supported by any portion of the joint.

Depressions for joints, other than bell-and-spigot, shall be made in accordance with the recommendations of the joint manufacturer for the particular joint used.

17-3.2.3 Fine Grading

Unless otherwise specified in the plans and/or special provisions, the bottom of the trench shall be accurately graded to provide uniform bearing and support for each section of the pipe at every point along its entire length, except for portions of the pipe where it is necessary to excavate for bells and for proper sealing of the pipe joints.

17-3.2.4 Over-excavation

Except at locations where excavation of rock, hardpan, or other unsuitable material from the bottom of the trench is required, care shall be taken not to excavate below the depth indicated.

Unauthorized excavation below the specified grade line shall be refilled at the Contractor's expense with an approved granular material compacted to a uniform density of not less than 95 percent of the maximum density as determined by ASTM D-1557 and D-3017.

Whenever rock or hardpan material is encountered in the trench bottom, it shall be over-excavated to a minimum depth of six inches below the O.D. of the pipe. This over-excavation shall be filled with an approved granular material placed with the minimum possible compaction.

17-3.2.5 Excavation for Manholes, Valves, Inlets, Catch Basins and Other Accessories

Structures shall be over-excavated at least twelve inches (12") beyond dimensions of structures as shown on the plans. If the native material is such that it will not stand without sloughing or if precast structures are used, the Contractor shall over-excavate to place the structure and this over-excavation shall be backfilled with the same material required for the adjoining pipe line trench.

17-3.2.6 Pavement and Concrete Cutting and Removal

Where trenches lie within the portland cement concrete section of streets, alleys, driveways, or sidewalks, etc., such concrete shall be sawcut to neat, vertical true lines in such a manner that the adjoining surface will not be damaged. The minimum depth of cut shall be 1 ½ inches or 1/4 of the thickness, whichever is greater.

No ripping or rooting will be permitted outside limits of cuts. Surfacing material removed shall be hauled from the job site immediately, and will not be permitted in the backfill.

17-3.2.7 Grading and Stockpiling

All grading in the vicinity of trench excavation shall be controlled to prevent surface water from flowing into the trenches. Any water accumulated in the trenches shall be removed by pumping or by other approved methods.

During excavation, material suitable for backfilling shall be piled in an orderly manner, a sufficient distance back from the edges of trenches, to avoid overloading and to prevent

slides or cave-ins. Material unsuitable for backfilling, or excess material, shall be hauled from the job site and disposed of by the Contractor.

The Contractor shall, prior to final acceptance of the Work, submit a letter to the City stating the location of each disposal site for all excess or unsuitable material and certify that he has obtained the property owner's permission for the disposal of all such materials.

17-3.2.8 Open Trench

Except where otherwise noted in the special provisions, or approved in writing by the Engineer, trenches shall be excavated only as far in advance of pipe laying as can be backfilled in the same day. The maximum total length of open trench shall be 185 meters (600'), except where approved in writing by the City Engineer.

Any excavated area shall be considered open trench until all aggregate subbase material for pavement replacement has been placed and compacted. With the approval of the engineer, pipe laying may be carried on at more than one separate location, the restrictions on open trench applying to each location. Trenches across streets shall be completely backfilled as soon as possible after pipe laying.

Substantial steel plates with adequate trench bracing shall be used to bridge across trenches at street crossings where trench backfill and temporary patches have not been completed during regular Work hours. Safe and convenient passage for pedestrians shall be provided. The Engineer may designate a passage to be provided at any point he/she deems necessary. Access to hospitals, fire stations and fire hydrants must be maintained at all times.

17-4 INSTALLATION OF PIPE

Proper facilities shall be provided for stringing and lowering sections of pipe into the trench. The pipe shall be laid carefully to lines and grades given.

The grade line shown on the plans indicates the flow line or invert of the pipe and all cuts, unless otherwise indicated, refer to this line.

After the trench for pipe has been brought to the proper line and grade, the pipe shall be laid in the following manner:

Pipe laying shall begin at existing sewer locations and shall proceed upgrade with the bell or groove end of the pipe placed upstream. Each section of pipe shall be laid true to line and grade and in such a manner as to form a watertight, concentric joint with the adjoining pipe. Existing sewer lines and flow therein shall remain operational at all times. Any rerouting or blockage of sewer flows during construction, by the Contractor, shall require approval by the City Engineer.

Sewer pipe and fittings shall be laid and jointed in compliance with the manufacturer's recommendation and shall be carefully adjusted to grade by scraping or filling and tamping the trench bottom. Each joint of pipe must be fully pressed into place so that there will be no unevenness or settlement of one length of pipe with the other at the joint. Circular reinforced concrete pipe with elliptical reinforcement shall be placed with the minor axis of the reinforcement in a vertical position.

The Contractor shall furnish and use, for grade and alignment control, a laser beam system which complies with OSHA requirements. The laser system shall have good visibility when used with suitable target material. The laser system must be of the self-leveling type so that the laser beam is automatically compensated for minute grade disturbances.

The laser system must also have an early warning system that instantly warns the pipe layer when the laser is off grade. The laser system is to be provided by the Contractor and shall have a minimum accuracy of ± 0.01 foot per one hundred feet (100') on line; and a minimum visible range of one thousand feet (1000'). When conditions are such that this method is impractical, such as on short pipe runs, the Contractor shall have an Engineer on the ground to set grade of each joint of pipe by means of an Engineer's level.

The grade line shown on the Plans indicates the flow line or invert of the pipe and all cuts, unless otherwise indicated, refer to this line.

The interior of the pipe shall be kept free from dirt, excess mortar and other foreign material as the laying progresses. Pipe shall not be laid when the condition of the trench or the weather is unsuitable, in the opinion of the Engineer, because of water or mud which may interfere with proper jointing. All open ends of pipe and fittings shall be adequately and securely closed whenever the Work is discontinued. Any pipe which shows undue settlement or is damaged shall be taken up and replaced or relaid at the Contractor's expense.

All pipe shall be laid to true line and grade. Occasional variations will be permitted as follows: above grade, 5mm (1/4 inch); below grade, not to exceed 10mm (1/2 inch); alignment not to exceed 50mm (2 inches) if gradual and regular over a distance of 6m (20 feet).

17-5 COMPACTION OF TRENCHES

17-5.1 Foundation and Bedding

The material upon which the conduit or structure is to be placed shall be accurately finished to the grade or dimensions shown on the plans or as directed by the Engineer. The bottom portion of the trench shall be brought to grade so that the conduit or structure will be continuously in contact with the material on which it is being placed.

Trenches bottoming in hardpan shall be excavated a minimum of 150mm (6") below the grade established for the bottom of the pipe and any couplings and then backfilled to the pipe grade with select material, thoroughly compacted. No additional payment will be made for such over-excavation and refill.

Whenever the bottom of the trench is soft, yielding or unsuitable as a foundation for the pipe, such material shall be removed to a minimum of 300mm (12"), or to a depth determined by the Engineer, below the bottom of the pipe or structure, and for a width equal to at least $\frac{1}{2}$ diameter on each side of the pipe, and the space backfilled with sufficient clean granular material of the type directed by the Engineer to insure a proper

foundation. No additional payment will be made for over-excavation or placement of clean foundation material unless so indicated in the Special Provisions or approved by the Engineer.

The maximum width of the trench at the top of the pipe shall not be greater than that specified in Table 17-3.1, unless otherwise specified on the approved Plans or Special Provisions for the Project.

Trenches shall be excavated to the depths required for the foundation of sewer pipes and their appurtenances shown on plans and where conditions make it necessary to such depths as may be directed by the Engineer. The use of blocks as support is forbidden. An additional depth and width shall be hand dug at joint or bell locations of sufficient depth to relieve the bell of any load and to allow ample space for making the joint.

Where the pipe is to be laid on sand having less than optimum moisture, as determined by the Engineer, the Contractor shall apply sufficient water and compact the sand prior to placing the pipe.

17-5.2 Pipe Embedment Zone

Pipe Embedment Zone shall be defined as that material supporting, surrounding, and extending to 0.3m (12") above the top of the pipe. Material used for backfilling within the Pipe Embedment Zone shall consist of the following select natural material or processed product Class II or Class III material as defined herein and shall be compacted to a minimum 90% as determined by ASTM D1557 (latest editions).

Class II: (E' = 3000 psi)* Washed concrete sand conforming to Caltrans Section 90-3.03.

Class III: (E' = 2000 psi)* Select natural sand and coarse silty sand conforming to the following particle size gradation and sand equivalent:

Sieve Size	Percent Passing
19mm (3/4")	100
4.75mm (#4)	> 50
(#200)	35 Maximum
Sand Equivalent	20 Minimum

* E' = modulus of subgrade reaction

17-5.3 Initial Backfill

Initial backfill shall be the material between the top of the bedding material and 0.3m (12") above the top of the pipe.

Initial Backfill shall consist of placing and firmly compacting selected granular backfill material under the haunches of the pipe and up to the spring-line of the pipe, and then filling to a level 300mm (12") above the top of pipe

Initial backfill shall be placed immediately after the pipe has been laid to line and grade in the trench, inspected and passed by the Engineer. The material shall be carefully placed so as not to disturb or damage the pipe or its placement, and shall be brought up evenly on both sides. Initial backfill material shall be backfilled to one foot (1') above the top of the pipe, in layers not to exceed eight inches (8") in depth and tamped by hand or pneumatic tampers to a relative compaction of 90% as determined by ASTM D1557.

The method of compacting and obtaining density requirements for all pipe trenches shall be such that the backfill material shall be completely compacted around the lower haunches of the pipe, such that line and grade of the pipe is not disturbed, and the pipe is not damaged.

Where the City's water system is utilized for construction water, the Contractor shall obtain a water meter from the Public Works Department (fire hydrant meter are required for all users). The Contractor shall obtain the permission as to which hydrants are to be utilized. Jetting of trench backfill is allowed with provisions, as stated below. Flooding of trenches from the top is not permitted.

1. Jetted Backfill - Jetting will be permitted when at minimum, the backfill and the sidewall native soils in the lower one-third of the trench depth are self-draining and possess a sand equivalent of not less than 20. Jetting shall be accomplished by the use of a jet pipe to which a hose is attached, carrying a continuous supply of water under pressure.
2. The jet pipe shall consist of a minimum 1 ½" diameter pipe to which a minimum 2" diameter hose is attached at the upper end. The jet shall be of sufficient length to project to within 2 feet of the bottom of the lift being densified.
3. The Contractor shall jet to within 2 feet of the bottom of the lift and apply water in a manner, quantity and at a rate sufficient to thoroughly saturate the thickness of the lift being densified. The jet pipe shall not be moved until the backfill has collapsed and the water has been forced to the surface.
4. The lift of backfill shall not exceed that which can be readily densified by jetting, but in no case shall the undensified lift exceed 10 feet.
5. Suitable backfill material to be jetted shall have a sand equivalent of 20 or greater.
6. Where the nature of the material excavated from the trench is generally unsuitable for jetting, the Contractor may, at no cost to the Agency, import from an approved source suitable material for jetting or densify the excavated material by other methods as approved by the Engineer. The backfill shall be allowed to thoroughly drain until the surface of the backfill is in a firm and unyielding condition prior to commencement of any subsequent improvements. The Engineer may require the Contractor, at the Contractor's expense, to dig a sump and provide a sump to remove any accumulated water.

7. The Contractor shall make its own determination that jetting will not result in damage to adjacent structures or facilities. Any resulting damage shall be repaired at the Contractor's expense.
8. The Contractor shall have available a continuous supply of water at a minimum pressure of 40 psig. If a water truck is used to supply water, it shall have a pump capable of supplying water at 40 psig and shall have the capacity to jet the trench without refill.
9. Once jetting has occurred, the fill shall be compacted with a "hydrahammer" drop weight type of compactor. The backfill depth shall not exceed the capacity of the compacting device in achieving 90% percent compaction in a single lift or 10 feet, whichever is less, the compaction in the top 2' shall be 95%.

17-5.4 Final Backfill

Final Backfill shall be the material above the Initial Backfill and consist of sound earthen material which is free of all rocks, hardpan, paving material, organic matter, broken concrete, wood or other deleterious material. Unless otherwise specified, this may be selected native material with no piece larger than 50mm (2").

Backfilling of trenches shall be accomplished and constructed pursuant to these standards with the type of replacement noted on the plans or in the special provisions. Surface restoration shall be accomplished and constructed per Standard Drawing No. ST-29.

Backfilling of trenches above the initial backfill as indicated in Section 17-5.3 above shall be as follows;

Where mechanical compaction is used, the moisture content shall be such that the specified compaction can be obtained and the backfill shall be placed in lifts the height of which shall not exceed that which can be effectively compacted depending on the type of material, type of equipment and methods used, and under no circumstances shall exceed 4 feet.

All backfill shall have a relative compaction of 90% to within twenty-four inches (24") of the surface and the top twenty-four inches (24") shall have a relative compaction of 95%. Test Method ASTM D 1557 shall be used to determine relative compaction, using the dry random sampling method (dry weight basis).

No free water will be allowed in the top twenty-four inches (24") of backfill.

Backfill, around utilities that are exposed during trench excavation, shall be placed in accordance with the above bedding, backfill, and compaction methods.

17-6 CONNECTION OF SERVICE LATERALS

Service laterals shall be furnished and installed by the Contractor at the locations shown on the Plans. Installation shall conform to the requirements Subsection 17-2, "Materials",

of these Specifications, and shall be installed in accordance with Standard Drawing No. S-12A, S-12B and S -13 of the City Standard Drawings.

The Contractor shall place as many "Y" branches of the size designated as directed. The "Y", unless otherwise specified, shall be inclined at any angle not greater than 45% from the horizontal.

Each "Y" branch, or the end of the sewer which does not terminate in a manhole, shall be closed at the bell with a cap made for that purpose.

17-7 INSTALLATION OF SEWER HOUSE BRANCHES

Sewer house branches shall be constructed in accordance with Standard Drawing No. S-12A, S-12B and S -13 of the City Standard Drawings. No sewer house branch shall be connected to sewer main within five feet (5') from the outside of a manhole.

Sewer house branches 100mm (4") in diameter may be connected to all sewer mains less than 460mm (18") in diameter at prefabricated wye fittings. Sewer house branches 100mm (4") in diameter may also be connected directly to existing sewer mains 460mm (18") to 685mm (27") in diameter , providing that a machine core is utilized to connect to the main sewer. Direct connection to mains larger than 685mm (27") in diameter shall only be approved in special cases where approved by the Engineer. Connection to these sewer mains by means other than a machine core will not be allowed. House branch sewers 150mm (6") in diameter or greater connecting to sewer mains shall require the construction of a manhole at the point of connection.

House branches shall be constructed at locations shown on the plans or as may be directed by the Engineer and shall extend from the outlet of the "Y" branch at the sewer main to ten (10) feet behind the right-of-way line of the street or alley, where the house branch shall be promptly closed at the bell end with a plug approved by the manufacturer of the pipe for use with his product.
for that purpose.

The slope and general arrangements of the house branches shall be as shown on the plans.

Excavations for laying house branches shall be made in such a manner that at no time will the street be closed to traffic. Whenever house branches are to be installed in major streets that have been resurfaced within the last five (5) years, or in pavement that is in good condition and free of cracking, they shall be installed by boring methods rather than open cuts trenches.

Where curb and gutter exists, or is to be constructed concurrently with sewer facilities, the location of each sewer service shall be permanently indicated by inscribing the letter "S" two inches (2") in height in the curb directly above the line when the service is perpendicular to the street centerline. Otherwise, the "S" mark for skewed or angling services shall be placed at a right angle to the end of the service. When sewer services are installed in an existing street, the curb mark shall be placed at the time the service is installed to assure proper location. In cases where a concrete curb does not exist, the Contractor shall mark the location of the terminus of the house branch by driving a one-

half inch (1/2") iron pipe or rod in the end of the trench before backfilling. The pipe or rod shall extend to within six inches (6") of ground surface.

Trenches left open for immediate connections need not be marked if a trap is installed at the curb. If a trap is not installed the marking of the house branch location will be used.

In new subdivisions where sewer services are installed before the curb is constructed, it shall be the Contractor's responsibility to establish the exact location of each sewer service and to furnish this information to the Engineer.

17-8 MANHOLE CONSTRUCTION AND DROP SEWER CONNECTIONS

17-8.1 General

Manholes shall be constructed in accordance with Standard Drawings S-1 through S-6 of the City Standard Drawings and as specified herein or directed by the Engineer. Manholes shall be complete structures in place and backfilled including the furnishing and placing of all materials involved. Precast concrete pipe manholes shall consist of a poured in place concrete base section, reinforced concrete pipe section(s), cast iron frame and cover and a poured in place concrete collar. Invert channels shall be smooth and semicircular in shape conforming to the inside of the adjacent pipe invert, or flow channels may be provided by use of the bottom half of the specified main pipe. The floor and wall of the manhole outside the channels shall be smooth and shall slope 1:12 towards the channels.

The top of the manhole base section shall be keyed to receive the tongue end of the riser section. The key shall be formed in the freshly poured concrete by using a template manufactured to the dimensions of the riser section. If the riser is cast-in-place monolithically with the base section by using a slip form or other means, the key may be omitted between the base and riser. If the base and riser sections are not poured monolithically, but separately, a key shall be provided in the base section. In either case, a key will be required in the top of the riser section to receive the tongue end of the tapered cone.

The joints between the base and all precast elements of the manhole, including adjustment rings and manhole frame, shall be filled with cement mortar, or approved equal, prior to joining the elements.

The interior of the manhole shall be troweled smooth with a wooden trowel, removing excess mortar extruded out of joints for the entire height of the manhole, from the manhole frame to the floor. All excess mortar and any other debris shall be removed from the manhole.

17-8.2 Design and Spacing

Sewer lines shall be laid straight between manholes, unless otherwise specified in the Plans and/or Specifications. The installation of lamp holes or clean-outs on public sewer mains is forbidden.

Manholes are to be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; and at distances not greater than 500 feet. Service connections into manholes is discouraged, except in cul-de-sacs. Where permitted, the invert of Service connection shall not be installed above the top of the sewer main line. A grade drop of 30mm (0.1') min. shall be provided through manholes, when grade permits.

Manholes shall not be installed in sidewalks, flow channels of gutters, or in depressions subject to storm waters or other infiltration.

Flat-top manholes are not permitted. Minimum depth of manhole above the manholes base shall be 1.08 m (42").

17-8.3 Materials

Pre-cast concrete pipe manholes shall consist of a poured in-place concrete base section, reinforced-concrete pipe section(s), a reinforced concrete taper section, grade rings and cast-iron frame and cover. Precast sections shall be manufactured in conformity to Class II, ASTM Designation: C-76-(Latest Revision) for their respective diameters.

Elliptical single-line reinforcement will not be permitted. Single line circular reinforcement will be permitted and the minimum steel area shall equal the minimum steel area required for the inter-cage reinforcement.

Tapered sections shall conform to the requirements for pipe of the size equal to the largest internal diameter of the tapered sections.

Concrete for the base section shall be Class A. Precast manhole bases are not allowed.

17-8.4 Installation

The inside of the manhole shall be formed to the flow line of the sewer. The formed flow channel depth shall extend above spring line up to 2/3 the diameter of the pipe. The bench shall slope a minimum 1:12. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of the channels shall be made gradually and evenly.

A channel shall be formed and extended completely through a starting manhole.

Stub-outs shall be installed in manholes at the locations and sizes shown on the Plans. All stub-outs shall be sealed with a plug of a type approved by the manufacturer of the pipe.

All manholes shall be completed to finish grade with concrete collar. In undeveloped areas where no street or alley surfacing is to be done in conjunction with or immediately after utility installation, the manhole cover shall be finished off to a level 25mm (1") above ground elevation and shall be provided with 300mm (12") grade rings. In existing street areas where surfacing exists and no new street regrading is contemplated in conjunction with or immediately after utility installation, such as new subdivisions, manholes shall initially terminate with the top of the cone 150mm (6") below subgrade

and shall be brought to street or alley surface with grade adjustment rings and completed after street paving is accomplished. Unless specifically otherwise indicated in the Special Provisions, it will be the responsibility of the Sewer Contractor to return and install the manhole covers to finish grade as specified and shown on the Standard Drawings.

The Contractor should be aware that connections to existing sewers will be "wet" and the Contractor shall make whatever arrangements are necessary to complete the manhole connections under the "wet" conditions.

Where necessary, manholes shall be equipped with an approved water-tight insert placed under the manhole cover to prevent rainwater or other inflow.

No steps shall be installed in manholes unless otherwise noted on the Plans.

17-8.5 Removal

Manholes abandoned in place shall be broken out within 0.9m (3') of the finished grade.

The manhole frame and cover will be delivered to the Public Works yard. The sewer mains entering the manholes shall be sealed with concrete and the manhole backfilled with sandy soil and compacted to a relative compaction of 90% using optimum moisture and tested in accordance with ASTM D1557.

Manholes to be removed shall have the base removed with the barrel and taper. The manhole frame and cover will be delivered to the City Corporation Yard. After the complete manhole has been removed the excavation will be backfilled in accordance with backfill requirements. Before backfilling, all sewer pipes that have entered the manhole will be sealed with concrete.

17-8.6 Adjustments

Where existing manholes need to be raised or lowered to meet a new street grade, they will be left in place and marked until the street has been paved. After the paving material has been compacted they will be dug out and the ring and cover removed and lowered or raised to grade by use of concrete around the frame. "Jiffy Rings" for raising manholes will be allowed.

17-8.7 Drop Sewer Connections

Drop sewer connections at manholes shall be constructed in accordance with Standard Drawings S-4 and S-5 and only at locations approved by the Engineer and shown on the approved plans.

17-8.8 Payment

If existing manholes are to be removed and replaced they shall be included in the bid price of new manholes unless otherwise specified in the special provisions. The bid price of adjusting manholes to the new street grade shall include surface restoration.

17-9 THIMBLES

Thimbles shall be installed in the manholes at the locations and of the size shown on the plans.

All thimbles shall be sealed with a plug of a type approved by the manufacturer of the pipe for use with his product.

17-10 DEFLECTION TEST OF PVC SEWER LINES

PVC sewer pipe, which is designated as flexible in nature, shall be tested for excessive deflection. This test shall be performed after backfilling and compaction but prior to the placement of aggregate base or asphalt-concrete surfacing, and prior to television inspection as specified in Subsection 17-12, "TELEVISION INSPECTION OF INSTALLED PIPE", of these Specifications.

The Contractor shall demonstrate that the maximum pipe deflection does not exceed 5 percent by pulling a properly sized rigid ball or a mandrel through the main line pipe. A "rubber flush ball" does not meet this requirement for deflection testing.

Failure of the deflection test shall be grounds for rejection of the section tested, until correction of the reason for the failure and successful retesting of the section.

17-11 AIR TEST ON SEWER MAIN AND SERVICE LATERALS

After completing the installation, backfill and compaction of a section of sewer line with service laterals, and after all other underground utilities (including gas, electric, telephone, cable television, water and storm drain) are in and compacted, but prior to the placement of aggregate base or asphalt-concrete pavement, the Contractor shall, at his expense, conduct a leakage test using low pressure air. The test shall be performed using the following procedures and under the supervision of the inspecting Engineer.

Each section of sewer between two successive manholes shall be tested by plugging all pipe outlets with suitable test plugs.

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 170 MPa (25 pounds per square inch) gauge pressure. The sealed pipe shall be pressurized to 35 MPa (5 psig). The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.

To commence the leakage test, air shall be slowly added until the internal pressure is raised to 27 MPa (4.0 psig). The compressor used to add air to the pipe shall have a blow-off valve set at 35 MPa (5 psig) to assure that at no time the internal pressure in the pipe exceeds 35 MPa (5 psig). The internal pressure of 27 MPa (4 psig) shall be maintained for at least two minutes to allow the air temperature to stabilize after which the air supply shall be disconnected and the pressure reduced to 24 MPa (3.5 psig). The time in minutes that is required for the internal air pressure to drop from 24 MPa (3.5 psig) to the lower pressure indicated in the appropriate table below shall be measured and the results compared with the values tabulated below.

Gauges used to measure test pressures shall read from 0 MPa (0 psig) to 69 MPa (10 psig) maximum with 3.5 MPa (½ psig) increments. If required, the contractor shall supply necessary fittings to accept a City supplied gauge.

All gauging and testing shall be done outside the manholes and no one shall be allowed to enter the manholes while the line is pressurized.

PVC Gravity Sewer Pipe

Minimum Acceptable Time Required for Pressure decrease from 24 MPa (3.5 psig) to 20 MPa (3.0 psig)

Pipe Diameter mm (inches)	Test Time	
	(Minutes)	(Seconds)
100 mm (4)	2	32
150 mm (6)	3	50
200 mm (8)	5	6
250 mm (10)	6	22
300 mm (12)	7	39
380 mm (15)	9	30

Vitrified Clay Sewer Pipe

Minimum Acceptable Time Required for Pressure decrease from 3.5 to 2.5 psig

Pipe Diameter (Inches)	Test Time		Minimum Distance Between Manholes	
	(Minutes)	(Seconds)	(Feet)	K Value
4	2	0	430	0.428
6	2	45	380	0.592
8	3	45	320	0.702
10	4	46	260	1.100
12	5	40	215	1.580
15	7	0	170	2.470
18	8	36	145	3.560
21	10	6	125	4.850
24	11	6	105	6.340
27	12	42	95	8.020
30	14	1	85	9.900
33	15	0	75	12.000
36	16	41	70	14.300
39	18	5	65	16.700
42	19	24	60	19.400

The above-tabulated values shall be used for the respective diameter pipes except where the distance between successive manholes is less than the above-tabulated values, in which case, the following formula will be used to determine the test time.

1. $T = KL$

2. T= test time in seconds
3. K= value from table
4. L= distance between successive manholes in feet

Failure of the leakage test will be grounds for rejection of the section tested, until discovery and correction of the reason for the failure and successful retesting of the section.

17-12 TELEVISION INSPECTION OF INSTALLED PIPE

The Contractor shall furnish closed circuit television inspection for an interior inspection of the newly installed sewer mains. The television check of the sewer mains shall be made after leakage and deflection tests have been performed and prior to placing of street aggregate base or asphalt paving. Any broken pipe, separation of joints, or any pipe exceeding the permitted tolerances for line and grade shall be replaced or repaired.

Any pipe repaired or replaced as a result of television inspection shall be retested for leakage and deflection. A tape cassette of the television inspection (standard DVD format) shall be provided the City at no additional cost to the City. The contractor shall be responsible for all costs associated with furnishing the television inspection and making final repairs to the sewer mains and reinspection utilizing the closed circuit television equipment.

At the request of the Contractor, the City may at its option perform the closed circuit television inspection or reinspection on the Contractor's installation at a cost designated in the City's Master Fee Resolution for such Television Inspection Work.

Requirements for Sewer Video Inspections:

1. The testing Company is to certify as to their ability to adequately perform the video inspection.
2. The City Inspector will provide 24 hour notice of testing schedule and will be present to monitor the test.
3. A flush truck will be required to be on-site to aid in the video inspection.
4. A video dvd shall be submitted to the City as proof of inspection and be certified to comply with plan requirements or pointing out by station any defects found.
5. Lateral lines to be documented by stationing from center line of manhole and the testing firm shall provide a map of the tested lines.
6. A chronological log of the test performed should correlate between the sewer plans and the tape produced.

17-13 MEASUREMENT

Measurement for sewer main installation and service lateral installation shall be by the lineal feet of pipe installed, and shall be the actual horizontal length installed, measured through wye fittings.

Measurement for wye fittings shall be per each wye fitting installed.

Measurement for manholes shall be per each manhole installed.

17-14 PAYMENT

The unit price bid per lineal foot for sewer mains shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the Work involved therein as shown on the Plans, as set forth in the Specifications, and as directed by the Engineer. This shall include, but not be limited to, furnishing and installing the pipe, trenching, backfilling, compaction, testing and internal inspection.

The unit price bid per lineal foot for service laterals (house branches) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the Work involved therein as shown on the Plans, as set forth in the Specifications, and as directed by the Engineer. This shall include, but not be limited to, furnishing and installing the pipe, trenching, backfilling, compaction, testing.

The unit price bid per each for wye fitting shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the Work involved therein as shown on the Plans, as set forth in the Specifications, and as directed by the Engineer, in excess of the cost of installing the main line pipe and service lateral. This shall include, but not be limited to, furnishing and installing the wye fitting and plug, trenching, backfilling, compacting, testing and internal inspection.

When the contract does not include a pay item for wye fittings as above specified, and unless otherwise provided in the Special Provisions, full compensation for wye fitting shown on the Plans shall be considered as included in the prices bid for other sewer pipeline items of Work and no separate payment will be made therefore.

The unit price bid per each for manholes shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the Work involved therein as shown on the Plans, as set forth in the Specifications, and as directed by the Engineer. This shall include, but not be limited to, furnishing and installing the manhole and stub-outs, backfilling and compaction, returning and adjusting manhole lids and frames to final grade following street or alley construction or reconstruction, and connection to all pipes, wet or otherwise.

No separate pay item will be included in the bid proposal, nor direct payment made for trench or structure excavation, backfilling, compaction, or placement of temporary pavement. The cost of these features of the Work shall be included in the unit price bid per linear foot for furnishing and laying pipe or installing structures.