
Chapter 9-3

SANITARY SEWER SYSTEM STANDARDS

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9-3-1: General Provisions

(A) **General.** A Registered Professional Engineer licensed to practice in the State of Colorado shall design sanitary sewer systems. Designs shall comply with the latest edition of the Colorado Department of Public Health and Environment Water Quality Division design regulations and City Sanitary Sewer System Standards. All proposed construction shall follow recommendations provided in the City Sanitary Sewer Collection System Master Plan, as adopted and revised.

(B) **Future Extensions.** Where it is determined that sewer mains are necessary to serve property beyond the subdivision or development in question, the developer will be required to design and construct his system, properly sized and at an appropriate location, to permit future extensions to be made at the limits of the subdivision or development in question. The system must terminate at all points in new development to within one lot from the adjacent and/or upstream properties to be served by the system in the future. Public sanitary sewer collection systems must be designed and constructed along major roads and/or through the development to facilitate future extensions. In selecting routes for sewer mains, the Public Works Department requires that the location must be such that it maximizes the potential for serving areas and/or future developments.

- (C) **Quality Control and Quality Assurance.** Quality Control shall be in accordance with Section 9-1-1 (B). Quality Assurance testing shall follow the general guidance of Section 9-1-1 (C) and specific requirements of Table 1 below.

(1) Table 1 – Required Quality Assurance Testing

TEST REQUIRED	TEST PROCEDURE	REQUIRED OR ALLOWED RANGE	MINIMUM TEST FREQUENCY
Compaction of bedding and haunching materials (except crushed rock)	AASHTO T 99 And T 265	90% minimum (see notes)	1 per 400 L.F. of trench (and each branch or section of trench less than 400 feet in length) for each two-foot vertical depth of backfill material.
Trench Compaction to subgrade 1. Within right of way. 2. In unimproved areas outside of right of way or within landscaped areas.	AASHTO T 180 And T 265	95% minimum (see notes) Match existing or 85% minimum	
Compaction of aggregate base course material	AASHTO T 180 And T 265	95% minimum (see notes)	1 per 200 S.Y.
Compaction within 24" of all structures (manholes, catch basins, vaults, etc.)	AASHTO T 180 And T 265	95% minimum (see notes)	1 per each two-foot vertical depth of backfill material or per 100 L.F. of structure perimeter

Notes:

Compaction of Clay soils – Compaction requirements per test procedure at optimum moisture to plus four percent (+ 4%)

Compaction of Non clay soils – Compaction requirements per test procedure near optimum moisture plus or minus two percent ($\pm 2\%$)

- (D) **Materials.** All materials used shall be new and in conformance with the applicable standards.

- (1) **Material Requirements:** All materials shall conform to the requirements of these specifications. The type, size and strength class of pipe, fittings and other materials shall be as shown on the Construction Drawings.

- (2) **Inspection and Testing:** All pipe shall be tested in conformance with the applicable standards. Testing may be witnessed by the Engineer's representative, or by an approved independent testing laboratory. Upon request of the Engineer, the Contractor shall provide a copy of certified test reports indicating that material does conform to the applicable standards or specifications.
- (3) **Handling:** All materials shall be handled with equipment and methods adequate to prevent shock or damage. Under no circumstances shall materials be dropped. Pipe handled on skids shall not be skidded or rolled against pipe already on the ground. If any part of the coating or lining is damaged, the Contractor shall repair or replace the material at his expense as directed by the Engineer.
- (4) **Storage:** The Contractor will be held responsible for the safe storage and protection of all pipe and other materials delivered to the work site. The interiors of all pipe and fittings shall be kept free from dirt and foreign matter at all times. Gaskets for pipe joints shall be stored in a cool location out of direct sunlight. If sunburned pipe is utilized, the City requires that the contractor provide a manufacturer's certification that all warranties are still valid. The City reserves the right to reject sunburned pipe depending on the severity of the apparent damage. Any material that has been damaged before actual incorporation in the Work shall be repaired or replaced at the Contractor's expense.

9-3-2: Sanitary Sewer System Design Criteria

- (A) **General.** Gravity sanitary sewer systems shall be designed to provide average minimum velocities of two (2) fps and maximum velocities of ten (10) fps. Clay dams shall be utilized where the possibility exists that ground or surface water will follow the sewer trench, causing damage or undermining of pipe bedding.

Sanitary sewers shall remain fully operational during the one hundred (100) year flood. Sewers and their appurtenances located along streams shall be protected against the normal range of high and low water conditions, including the one hundred (100) year flood. Sewers located along streams shall be located outside of the streambed and no closer than thirty (30) feet from the top edge of the bank.

- (B) **Location of Sanitary Sewer Lines.** All sanitary sewers shall be located in existing or proposed streets and shall be constructed along the center of the street, center of the travel lane, or center of an alley. Exceptions to this specified location will be allowed only when it has been definitely shown that it is not practical to adhere to this requirement. All sanitary sewers shall be laid on a straight line between manholes.

- (C) **Sewer Line Separation Requirements.**

- (1) Lateral placement of sewers and water lines.

- (a) Sewers shall be laid at least ten (10) feet horizontally from any existing or proposed water line. The distance shall be measured edge-to-edge. There is no minimum vertical separation required provided the ten (10) foot horizontal separation is maintained.
- (b) Structures other than pipelines through which sanitary wastewater flows, such as, but not limited to, manholes, valve vaults, meter pits and pump station wet wells, shall also be constructed at least ten (10) feet horizontally from any existing or proposed water line, measured edge-to-edge.
- (c) In cases where it is not possible to maintain a ten (10) horizontal separation, the City may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the sewer pipelines and/or structures closer to a water line, provided that:
 - (i) The sewer pipeline and/or structures and water line are laid in separate trenches, or
 - (ii) The sewer pipeline and/or structures and water line may be installed in the same trench with the water line placed on a bench of undisturbed earth, and
 - (iii) In either case, the crown of the sewer pipeline shall be at least eighteen (18) inches below the invert of the water line.
- (d) In situations where it is impossible to obtain proper horizontal and vertical separation as stipulated above, the following protection shall be provided:
 - (i) Encasement of the sewer pipeline in concrete (min. six (6) inch thickness) or a carrier pipe for at least ten (10) feet either side of the area not complying with the minimum horizontal and vertical separation, or
 - (ii) The design and construction of the sewer pipeline must meet the requirements applicable to water lines (any AWWA-approved material for potable water conveyance), and pressure tested in accordance with AWWA specifications, or
 - (iii) In instances of conflict with sanitary wastewater structures mentioned above, relocate the water line to achieve either a ten (10) foot horizontal or 18 inch vertical separation.
- (2) Sewers crossing water lines. Sewers crossing over water lines should be avoided, but if conditions warrant this situation, then adequate structural support shall be provided for the sewer to maintain line and grade.
 - (a) Sewers crossing under water lines shall be laid to provide a minimum vertical separation of eighteen (18) inches between the invert of the water

line and the crown of the sewer. Relocation of an existing water line may be necessary to achieve this vertical separation. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water line joints.

- (b) Where conditions prevent an eighteen (18) inch vertical separation from being maintained, the following methods shall be specified:
- (i) The design and construction of the sewer must meet the requirements applicable to water lines (any AWWA-approved material for potable water conveyance) for a distance of ten (10) feet on each side of the crossing, measured perpendicular to the water line and pressure tested in accordance with AWWA specifications, or
 - (ii) Either the water line or the sewer may be encased in concrete (min. six (6) inch thickness) or a carrier pipe for a distance of ten (10) feet on each side of the crossing, measured perpendicular to the water line. The carrier pipe shall be designed and constructed of materials which are satisfactory to the City, or
 - (iii) Any other methods, if supported by data from the design engineer, which ensure adequate watertightness and are satisfactory to the City Engineer.

- (D) **Sewer Lines Installed within Borings.** Carrier pipe within bores for sanitary sewer installation shall be meet CDOT structural specifications.
- (E) **Sewer Lines at Railroad Crossings.** All sanitary sewer line crossings of railroads and, where required, roadways and other major structures shall be installed within a steel casing pipe. Design of railroad crossings shall comply with the requirements of Union Pacific Railroad, Utilities Installation Procedures. The engineer shall be responsible for the preparation of the necessary application, in advance of construction or advertisement for bid, for submission by the City to the railroad.
- (F) **Sewer Lines at Stream Crossings.** The tops of all sewers entering or crossing streams shall be a sufficient depth below the natural bottom of the streambed to protect the sewer line. In general, two (2) feet of suitable cover shall be provided where the stream is located in rock and three feet of suitable cover in other material. Less cover will be considered if the proposed sewer crossing is encased in concrete and/or ductile iron pipe is used and will not interfere with future improvements to the stream channel.

Sewers entering or crossing streams, estuaries, lakes, or reservoirs shall be constructed of watertight pipe. The pipe and joints shall be tested in place and shall exhibit zero (0) infiltration. Sewers laid on piers across ravines or streams shall be allowed only when it can be demonstrated that not other practical alternative exists.

Construction methods and materials of construction shall be such that sewers will remain watertight and free from change in alignment or grade due to anticipated hydraulic and physical loads, erosion, and impact.

- (G) **Depth of Sanitary Sewer Lines.** All sewer mains and service lines shall be designed so that a minimum of four (4) feet of cover exists over the pipe after final grade has been established, unless specifically approved by the City Engineer.

Sewer mains and service lines which have more than twenty (20) feet of cover shall be installed using pipe materials specified in subsection 9-3-3(B). Sewer lines which must cross under irrigation ditches or through bogs or swamps where the soil is unstable and water infiltration may be high, must be designed specifically for those conditions by the engineer and approved by the City Engineer.

- (H) **Sanitary Sewer Manholes.**

(1) **Location.** Manholes shall be located at the end of each line; at all changes in pipe size, alignment, grade; and at sewer line junctions. Maximum spacing between manholes on straight runs shall be four hundred (400) feet for sewers fifteen (15) inches or less and five hundred (500) feet for sewers eighteen (18) inches and larger.

(2) **Drop Manholes.** Drop manholes shall be used when the spring line elevation of the incoming sewer line is higher than the spring line elevation of the outgoing sewer line by two (2) feet or more.

(3) **Sampling Manholes.** Sampling manholes shall be installed at all commercial facilities located in business parks and industrial parks. This includes, but is not limited to, industrial facilities, food processing, metal processing, hospitals, animal hospitals, photographic finishers, printing shops, and any facility that the City feels may have an impact on the wastewater treatment plant.

(a) Physical design of the sampling point must be appropriate for the type of wastewater to be sampled. Manhole shall be located within fifteen (15) feet of the building and shall be accessible by City staff at all times.

(b) For further information, contact the City Engineer .

- (I) **Service Connections.** Service connections shall be provided in accordance with existing City specifications and details. Plugged service connections at full-body wyes are to be provided for all lots and parcels within the new development until extended to the dwelling unit. A minimum size of four (4) inch diameter pipe is required for residential sewer lateral connections.

- (J) **Structural Design.** Structural requirements must be considered in the design of all sanitary sewers and appurtenances. This is a matter of detail design and is not subject to simple generalization. The design engineer shall consider the following criteria:

- (1) **Special Structures.** Whenever possible sanitary sewer structures shall be built as shown in the *Sanitary Sewer System Details*. Structures other than those shown in the *Sanitary Sewer System Details* shall be considered special structures and shall be designed and detailed by the design engineer.
 - (2) **Pipe Foundation.** In all cases the proper strength sewer pipe shall be specified for the proposed depth, width of trench and bedding condition. Soil condition shall be considered with samples being obtained where necessary to verify pipe selection and foundation design.
- (K) **Hydraulic Design For Sanitary Sewers.** In general, the pipe diameter should be continually increasing with increase in tributary flow. Where steep ground slopes make possible the use of a reduced pipe size and substantial economy of construction costs is thereby indicated, the pipe size may be reduced, but hydraulic allowances shall be made to provide for head loss at entry, increased velocity, and effect of velocity retardation at the lower end where the flow will be on flatter slopes. In no case, should pipe sizes be thus reduced more than one (1) nominal size in diameter.

Hydraulic computations shall be submitted to the City Engineer for approval. Engineer shall submit with all sewer plans the information and calculations on sewer flow demands for the project. Upon receiving a written request from the developer and/or his agent and the information furnished by the developer's engineer, the City Engineer will provide the available sewer capacity. After evaluating this information on available capacities, the engineer shall then furnish his calculations supporting that these demands can be met and that the sizing of the proposed sewer mains is adequate. The quantity of sewage for design purpose shall be determined by the future requirements of the total drainage area tributary to the section of sewer under consideration.

- (1) Average quantities of sewage, including allowable infiltration, shall be computed as follows:

	Gallons per day per acre	Equivalent Persons/Acre
Residential		
Low Density (1.0-3.0 dwellings per acre)	500	5
Medium Density (3.1-7.0 dwelling units per acre)	1,000	10
High Density (7.1+ dwelling units per acre)	2,500	25
Other		
Agriculture/Undeveloped Land	1,000	10
Commercial		
Business	2,000	20
Regional/Commercial	2,500	25

Industrial		
Light	2,500	25
General	3,500	35

- (2) Where site-specific determinations can be made, sewage flows may be determined by using the following design information:

Discharge Facility	Design Units	Flow gpd
Single Family Units Includes Townhouses, Individual House Trailers	3.5 people/dwelling	350
Apartments and Condominiums	4 people/3 bedroom apt 3 people/2 bedroom apt 2 people/1 bedroom apt	350 300 200
Schools with showers and cafeteria		
Elementary	Per person	16
High School	Per Person	25
Motels and Hotels—rooms only	Per person	130
Restaurants	Per seat	50
Service Stations	Per vehicle serviced	10
Factories	Per person/8 hr shift	25
Shopping Centers	Per 1000 sq ft of Ultimate Floor space	250
Hospitals	Per bed	300
Nursing Homes	Per bed	200
Homes for the Aged	Per bed	100
Doctors Office in Medical Center	Per 1000 sq ft	500
Laundromats, 9 to 12 machines	Per machine	500
Churches and Theaters, Auditorium Type	Per seat	5
Bowling Alleys	Per lane	75
Office Buildings	1000 sq ft ultimate floor space	200
RV Parks	Per RV Parking Space	100

- (3) Design flow shall be calculated using current Colorado Department of Public Health and Environmental criteria. The engineer shall ensure that the following design criteria are adhered to:
- (a) Sewers shall have a continuous slope, straight alignment and uniform pipe material between manholes.
 - (b) At all junctions where a smaller diameter sewer discharges into a larger one, and at all locations where the line increases in size, the invert of the larger sewer shall be set so that the energy gradients of the sewers at the junction are at the same level. Generally, this condition will be met by placing the pipes at crown's level where possible. However, as a minimum, place the eighty percent (80%) depth of flow in each sewer at the same elevation.

- (c) Sewers shall be designed to be free flowing with the hydraulic grade below the crown and with hydraulic slopes sufficient to provide an average velocity, when flowing full, of not less than two (2) feet per second. Computations of velocity or flow rate shall be based on a value of "n" = 0.013 as used in the Kutter or Manning formula.
- (d) In cases where the calculated depth of flow is less than the pipe flowing full, the velocity at actual depth of flow shall be computed. The maximum depth of flow shall not exceed 0.8D, where D = Pipe Inside Diameter.
- (4) For sewage flow depth less than one-quarter (1/4) full, allowance shall be made for increased value of "n." In no case should velocities of less than two (2) feet per second be permitted. Increased velocities shall be accomplished by steeper grades.
- (5) The following are minimum slopes in feet per hundred feet to be provided for pipes flowing one-quarter (1/4) of full depth to full depth:

Pipe Size	8"	10"	12"	15"	18"	21"	24"	27"	30"	36"
Slope %	.40	.28	.22	.15	.12	.10	.08	.067	.058	.046

A minimum slope of 0.52% shall be maintained for terminal eight (8) inch lines not likely to be extended.

Minimum pipe size between manholes shall be eight (8) inch.

- (6) In cases where sewers are to be constructed on steep grades for which high velocities are indicated, the maximum permissible velocity at average flow (before applying peak flow factor) shall not exceed ten (10) feet per second. Suitable drop manholes shall be provided to break the steep slopes and to limit velocities to less than ten (10) feet per second in the connecting sewer pipes between manholes unless otherwise approved by the City Engineer.
- (7) Head Losses: Miscellaneous head losses at manholes, curves and junctions shall be estimated and allowed for as follows:
 - (a) At manholes on straight runs allow head loss = 0.05 feet.
 - (b) Ninety degree (90°) turns made inside of manholes, where the radius of turn is less than two (2) pipe diameters allow $0.50 V^2/2g$. If the radius of turn is greater than two (2) pipe diameters, allow $0.25 V^2/2g$. In no case should the total allowance be less than 0.05 ft.

- (c) At transitions and intersections of sewers larger than twenty-four (24) inches in diameter, allow $0.50 V^2/2g$.

9-3-3: Sanitary Sewer Material Specifications for Pipe, Pumps, and Fittings

- Fittings.** Service taps for new construction shall be accomplished utilizing a full-body wye fitting. For existing mains, tapping saddles will be used.
- (A) **Gravity Sewer Lines.** Sewer pipe and fittings shall be PVC and conform to ASTM D-3034 Type PSM for diameters four to fifteen (4 to 15) inches and to ASTM F-679 Type I for diameters eighteen to twenty-seven (18 to 27) inches. The minimum wall thickness for PVC pipe shall conform to Standard Dimension Ratio (SDR) 35. Joints shall be bell-and-spigot type with flexible elastomeric seals conforming to ASTM D-3212. Gaskets shall be neoprene or other synthetic rubber material conforming to ASTM F-477. The bells shall be integrally formed with the pipe or fitting.
- (B) **Pressure Sewer Lines.** Pipe used for sanitary sewers under pressure shall be either PVC or HDPE meeting the following requirements:
- (1) PVC: ASTM D-2241 (IPS), AWWA C-900. Joints shall conform to ASTM D-3139 and have elastomeric seals conforming to ASTM F-477. The type and pressure class shall be as shown on the Construction Drawings. PVC pipe fittings shall be fabricated of PVC material having a pressure rating equal to or greater than the pipeline used. PVC fittings may be used only with PVC pipe. When used with AWWA C-900 PVC pipe, sizes four through eight (4 - 8 inches), the PVC fitting shall conform to AWWA C-907. When used with ASTM D-2241 pipe, the PVC fitting shall be of the same or higher class as the pipe and the pipe rating shall be reduced by fifty percent (50%).
 - (2) HDPE: Pipe and connections shall conform to AWWA C901 one-half to three (½ to 3) inches or AWWA C906 four (4) inches and larger.
- (C) **Individual Lift Pumps.** Where a low-pressure sewer system incorporating individual lift pumps at each house is approved by the City Engineer, the pumps, including controls and enclosure, shall be Environment/One GP2000 Series installed in accordance with applicable manufacturer's recommendations.
- (D) **Collection System Lift Pumps.** Where a lift pump associated with a gravity flow collection system is approved by the City Engineer, the pump, controls, and enclosure package shall be "Smith and Loveless Wet Well Mounted" installed in accordance with manufacture's recommendations.
- (F) **Manholes for Sanitary Sewers.** Manholes shall be constructed as shown on *City Standard Details*.
- (1) Cement: All cement used in mortar, concrete bases, and precast manhole riser sections, cones and flat tops, for sanitary sewer manholes, shall be Type V or

modified Type II Portland cement having less than five percent (5%) tricalcium aluminate.

- (2) Precast Concrete Manhole Sections: Manhole risers, cones, flat tops and grade rings shall be precast reinforced concrete sections conforming to ASTM C-478 or AASHTO M-199. Manhole risers, cones and flat tops shall be made with tongue and groove ends for continuous and uniform joints between sections. The joint sealant shall be a flexible, preformed, bitumastic joint sealant.
- (3) Invert Epoxy Gel: All sanitary sewer manholes that are not constructed as a through manhole (pipe laid continuously through the manhole providing a PVC invert) shall have a minimum fall across the manhole of 0.16 feet. The concrete invert of the manhole shall have a steel trowel finish free of transverse or longitudinal trowel marks. Broom finishes are not acceptable.

In the event that 0.16 feet of positive fall cannot be maintained across the manhole, the manhole invert shall be coated with an epoxy gel material suitable for feathering and vertical application. Epoxy coating shall be Dayton Superior, Resi-Bond (J-58), or approved equal, applied according to manufacturer's recommendations.

In manholes with limited fall from pipe invert in to pipe invert out, the concrete invert may need to be ground to allow continuous positive fall through the manhole. Mix epoxy in accordance with the manufacturers instructions. Epoxy may be brush applied in thin coats to provide a slick surface through the concrete invert of the manhole. Epoxy seems to perform best if applied during the first ten (10) to twelve (12) minutes of pot life. The cured surface of the epoxy coating shall be free of brush marks and shall have a cross section consistent with that of the PVC pipe.

- (4) Manhole Waterproofing: All manhole section interfaces shall be waterproofed using a flexible sealant meeting or exceeding AASHTO M-198 specifications.

Corrosion Protection: All drop manholes, force main outlet manholes, and lift station wet wells shall be coated on the interior surfaces of the riser and cone with a minimum twenty (20) mil Dayton Superior Resi-Bond (J-58) or approved equal applied according to manufacturer's recommendations. City inspection of the manhole is required prior to application of the product to ensure proper surface preparation has been accomplished. The manufacturer's recommendations for application in confined space areas shall be followed.

Alternative to epoxy coating is white, premolded plastic sheet linings such as the Amer-Plate "T-Lock" as manufactured by Ameron, Corrosion Control Division, Brea, CA or approved equal. Joint and welding strip shall be Amer-Plate "T-lock" or approved equal. All work in connection with the installation of the plastic lining in precast manhole sections is to be performed in strict conformity with the lining manufacturer's recommendation. After the structure is installed

and backfilled, all surfaces covered with the T-Lock plastic lining, including welds, shall be tested with an electric holiday detector. The voltage and specific methods of testing shall be as recommended by the manufacturer of the lining material. In addition, all welds will be physically tested by non-destructive probing. All patches over holes or repairs to the liner wherever damage has occurred are to be made in conformance with the instructions and recommendations of the liner manufacturer. The Contractor is responsible for obtaining all testing equipment required to verify the integrity of the liner and welds.

- (5) **Manhole Steps:** Steps are required in all sanitary sewer manholes. Manhole steps shall be a manufactured copolymer polypropylene plastic step with one-half ($\frac{1}{2}$) inch diameter, Grade sixty (60) steel core. The steps shall be set in the wall of the manhole riser at the time the riser is manufactured. For precast manhole bases with integral riser sections, the steps shall be installed at a forty-five degree (45%) angle from the inlet pipe. The spacing between steps shall be such that when the manhole components are assembled the spacing is in conformance with OSHA Standards.
- (6) **Pipe-to-Manhole Connector:** Pipe-to-manhole connectors shall be manufactured with rubber conforming to ASTM C-923. All metal components shall be stainless steel.
- (7) **Rings and Covers:** Manhole rings and covers shall be cast iron dipped in asphaltic material to resist rusting. The standard City manhole shall be C.I. or approved, fully interchangeable substitute. The bearing surfaces between the ring and cover shall be machine finished or ground to assure non-rocking fit in any position and interchangeability. The cover shall have a beveled pick hole that has a width of three-quarter ($\frac{3}{4}$) inch at the top and one (1) inch at the bottom. The length of the pick hole (along the circumference of the lid) shall be at least one and one-half ($1\frac{1}{2}$) inches. The word SEWER shall be cast in the cover as shown on *Sanitary Sewer System Details*. Inverted rings and covers will not be allowed unless approved by the City Engineer.
- (8) **Watertight Manhole Covers:** Where a watertight manhole is required, the ring and cover shall be equipped with a gasket or o-ring, the cover shall have no holes that could allow the intrusion of water into the manhole, the ring and cover shall be drilled and tapped at one hundred twenty degree (120°) spacings, and three (3) stainless steel bolts shall be furnished to secure the cover to the ring. Anti-seize compound will be applied to threads PRIOR to installation. The standard ring and cover for watertight manholes shall be Castings MH-250-D-CI, bolted and gasketed, or approved equal.
- (9) **Cast Iron Grade Rings:** Under no circumstances will cast iron grade rings be permitted for new construction. Cast iron grade rings that fit in the top of existing manhole rings shall be the same diameter as the existing ring and shall have three setscrews for attachment to the existing ring.

- (G) **Concrete and Mortar.** All concrete used in construction of manholes, inlet boxes, vaults, concrete encasement, thrust blocks, etc., shall meet the requirements of the *Concrete Specifications*, and shall be made with modified Type II Portland cement.

Cement mortar used in construction or maintenance of manholes, inlets, vaults, etc., shall be a non-shrink grout conforming to ASTM C-109 and ASTM C-191. Rapid-Road Repair grout or approved equal is recommended for setting the ring and cover on top of the concrete grade rings. All-Crete 5 Minute Set (Fostroc Inc, Georgetown KY) or approved equal is recommended for invert work.

9-3-4: Sanitary Sewer System Installation Specifications

- (A) **Installation of Gravity Flow Pipelines.** All sanitary sewer facilities shall comply with current design criteria of the Colorado Department of Public Health and Environment.
- (B) **Pipe Laying of Gravity Flow Pipelines.** After the trench has been dewatered and the bedding prepared in accordance with subsection 9-3-5 below, the pipe shall be laid to the line and grade shown on the *Construction Drawings*. Variance from the designed location and elevation at the ends of every pipe section shall not be greater than three (3) inches horizontally and two (2) inches vertically while still maintaining minimum positive slope of the pipe. Variance from the design slope shall be within one-half percent (0.5%) of the design slope. At no point, however shall the slope be permitted to drop less than the allowed minimum positive slope for the pipe size used or the design slope on the *Construction Drawings*, whichever is less. A deflection of up to eight-tenths (0.8) inches, creating a sag of not longer than four (4) linear feet, will be allowed once in every one hundred (100) feet of pipe laid. If sag is identified during lamping the sewer line, the line will be televised, closed circuit, in accordance with subsection 9-3-6(L) to determine the severity of the deficiency.

The Contractor shall set the line and grade of each joint of pipe with a laser unless otherwise approved by the Engineer. The Contractor's surveyor shall set offset hubs at intervals of fifty (50), one hundred (100) and two hundred (200) feet from the laser's location. Whenever the pipe is found to be outside the specified limits, the misaligned sections shall be removed and relayed to the correct line and grade at the Contractor's expense.

Pipe shall be laid upgrade from the point of connection to the existing sewer or from a designated starting point. Pipe with bell and spigot joints shall be laid with the bell end upgrade.

The inside of the pipe and jointing surfaces shall be kept clean and free from mud, soil, gravel, groundwater, and other foreign material. When pipe laying is not in progress, the upgrade end of the pipe shall be kept closed with a tightly fitting cap or plug.

- (C) **Sewer Line Stub Outs.** Sewer line stub outs shall be no longer than twenty (20) feet unless otherwise approved by the City Engineer. The minimum length of a stub out shall be eighteen (18) inches. Service connections to stub-outs are not allowed. Each stub out shall be connected to the manhole with a Kor-n-seal gasket, or approved equal, and plugged with a PVC cap that can be removed for future extension, yet still prevent ground water infiltration.
- (D) **Installation of Sewer Service Lines.** Sewer service pipe within the public way shall be laid at a minimum grade of two percent (2%) unless otherwise approved by the Engineer. Flatter slopes between one percent and two percent (1% and 2%) will be considered only when there is not enough elevation difference to achieve two percent (2%). Prior to backfilling, a City inspector shall inspect sewer service pipe and connections to the sewer main. The Engineer shall establish the location and alignment of service lines.

The maximum deflection at any one (1) fitting or any combination of adjacent fittings shall not exceed ninety degrees (90°). Ninety-degree (90°) fittings shall be the long radius type.

- (E) **Small Diameter Taps.** Four (4) -inch service lines shall be joined to the new sewer mains with a full-body wye fitting connected above the spring line of the sewer pipe. On existing sewer lines, the method of connection may be by the installation of a tapping saddle with stainless steel straps. Where a tapping saddle is used, the hole in the main line shall be elliptical and slightly larger than that of the tapping saddle. The service line or wye shall not protrude beyond the inside wall into the sewer main.
- (F) **Large Diameter Taps.** Six (6) inch or larger service taps shall be accomplished using a manhole. On eight (8) inch or smaller main lines in which projected flows will be less than one-third ($\frac{1}{3}$) full, the six (6) inch service line shall enter the manhole approximately two tenth (0.2) feet higher than the invert of the existing pipe.
- (G) **All taps.** For the installation of sewer service lines to properties that will not be immediately connecting or reconnecting to the sewer system, the service lines shall be stubbed out to the house side of the multi-purpose easement, utility easement, or right-of-way line where no easement exists. The end of the pipe shall be plugged and marked with either a four by four inch (4" x 4") board or steel fence post buried vertically above the end of the pipe and extending three (3) feet above the ground surface with the exposed portion painted green. The ends of the service lines shall be capped with watertight plugs braced to withstand test pressures. The horizontal location of each service tap shall be measured and shown on the As-Built drawings prior to backfilling. The Contractor shall mark the end of the service with a post, as required above, with a reference mark and depth to the service pipe to be shot (for elevation) and documented at a later date. Tap locations shall be referenced using the stationing shown on the plans or referenced to property corners unless otherwise approved by the Engineer.

All service lines over one hundred (100) feet in length shall have a clean out installed in accordance with the Uniform Plumbing Code. When the clean-outs are within the right of way, the clean-out enclosure shall be constructed in accordance with *Sanitary Sewer System Detail SS-07* and shall be H-20 rated.

Sub-drains and/or French drains shall not be connected to sanitary sewers. Services for service stations, car washes, and food-processing establishments shall have a grease and/or sand trap installed on their service lines. The trap shall be constructed to the requirements of the City Engineer.

- (H) **Construction of Manholes.** The foundation for each manhole base shall be prepared by replacing unsuitable material with subgrade stabilization material in accordance with subsection 9-3-5(I) and placing granular bedding material in accordance with the *Sanitary Sewer System Details*.

The manhole base shall be precast or cast-in-place. The lines and grades of the pipe inverts shall be staked, as shown on the *Construction Drawings*. The inverts of sanitary sewer manholes shall be formed and smoothly finished to match the shape and elevation of all pipes connected to the manhole. Where the sewer line is designed with a continuous grade and horizontal alignment through the manhole, the line may be installed through the manhole, the top half of the pipe cut out for a length of at least three (3) feet, and the manhole base formed around the bottom half of the pipe. A precast base with a precast invert may be used where there is at least two-tenth (0.2) ft. of elevation difference across the manhole.

If cast-in-place bases are used, the first pre-cast manhole section shall be placed on the concrete base structure before the base has taken initial set, or the section shall be grouted into a suitable groove formed in the top of the manhole base. The first section shall be adjusted to the proper grade and alignment so that it is uniformly supported by the base concrete and not bearing on any of the pipes. The manhole steps shall be located forty-five degrees (45%) left or right of the main inflow pipe.

The remaining pre-cast sections shall be placed and aligned to provide vertical sides and alignment of the ladder rungs. Plumb shall be checked as each barrel section is added. A flexible sealant meeting or exceeding AASHTO M-198 specifications shall be placed between pre-cast sections so that the completed manhole is rigid and watertight.

The manhole ring and cover shall be adjusted to the final pitch and grade with mortar and precast concrete grade rings. The total height of grade rings shall not be more than twelve (12) inches. Grade rings shall be dry stacked and the cast iron ring set in a bed of mortar at the finished grade elevation. Cast iron grade rings shall not be used to adjust the elevation of the manhole lid, except when a street is being overlaid. Inverted rings and covers will not be permitted without the approval of the City Engineer.

Where the manhole is located in an unpaved street, alley or other area where grade has not been established, six to twelve (6 to 12) inches of concrete grade rings shall be placed between the top of cone and bottom of the ring (to allow future adjustment of the ring to grade).

Where the manhole is located in an unpaved area, a concrete collar with a #4 rebar hoop shall be cast around the ring and cover. The concrete collar shall be a continuous section with minimum dimensions of twelve (12) inches wide and twelve (12) inches thick.

Where a manhole is in a cultivated area, landscaped area, flood plain, or other area subject to inundation, a watertight manhole cover shall be used.

Manhole rims shall be six (6) inches above the one hundred (100) year flood elevation. Where the rim would be more than four (4) feet above the existing grade, in which case watertight covers shall be used and the manhole shall be set at a height four (4) feet above final grade.

All newly constructed manholes shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind, and shall be free from such accumulations at the time of final inspection. All ram-neck shall be trimmed flush with manhole wall.

9-3-5: Removals, Excavation, Backfilling, and Restoration Specifications

- (A) **Description.** This section covers surface removals, excavation, backfilling, compaction, disposal of surplus material, restoration of disturbed surfaces, and all other work required for the safe and proper construction of sanitary sewers.
- (B) **Survey Line and Grade.** All construction surveying and staking shall be performed by or under supervision of a professional engineer or land surveyor currently registered in the State of Colorado. The Contractor shall use a laser instrument to maintain and control the line and grade of all gravity flow pipelines including sanitary sewers, storm drains and irrigation lines. Checkpoints shall be set at fifty (50) feet, one hundred (100) feet and two hundred (200) feet from the beginning of each reach of pipe to assure that the laser is on the correct line and grade.
- (C) **Excavation Permits.** For any construction within City street rights-of-way, an Excavation Permit must be obtained from the Public Works Department prior to commencing the work.
- (D) **Removal of Structures and Obstructions.** The removal of structures and obstructions shall be in accordance with subsection 9-4-3 of the Street System Standards. The Contractor shall remove surface materials and obstructions only to the widths necessary for excavation of the trench. All trees, shrubbery, fences, plantings and structures not designated for removal shall be protected or, if moved, restored to their original condition after construction is complete.

Removal of concrete curbs, gutters, sidewalks, driveways, and asphalt pavement shall be along existing joints or neatly cut lines. All vegetation, concrete, asphalt, and other refuse removed from the construction limits shall be separated from suitable topsoil and backfill material, and hauled to a disposal site secured by the Contractor. Where the trench is in an unpaved area, clean topsoil suitable for final grading shall be stripped, stockpiled separately in approved locations, and restored to the original thickness after the trench is backfilled.

- (E) **Bracing and Sheet piling of Trenches.** All trenches shall be properly braced, sheeted or otherwise supported to provide safe working conditions and protection of the work, workers and adjacent property. Bracing, trench shields and sheet piling shall conform to the recommendations in the Occupational Safety and Health Standards for Construction (OSHA). All trench support materials shall be removed in a manner that will prevent caving of the sides and movement or other damage to the pipe.
- (F) **Trenches with Sloping Sides.** Where working conditions and right-of-way width permit, trenches in unimproved areas may be excavated with sloping sides in accordance with OSHA requirements. All soils shall be assumed to be OSHA Type C Soil, unless otherwise classified by a qualified soils technician. Trenching and other excavations shall not extend beyond existing easements, right-of-way or limits shown on the *Construction Drawings* unless otherwise approved by the property owner and the Engineer. Where trenches with sloping sides are permitted, the slopes shall not extend below a point twelve (12) inches above the top pipe.

In streets, alleys or narrow easements, trenches shall be excavated with vertical sides, properly braced and supported, unless otherwise approved by the City Engineer.

- (G) **Open Excavation Limits.** The length of open trench shall be kept to a minimum and shall not exceed the length necessary to accommodate daily pipe laying and backfilling operations unless otherwise approved by the City Engineer. The Contractor shall be responsible for covering or barricading unattended trenches and excavations as necessary for protection of the public and the work. All trenches and excavations shall be backfilled at the end of each workday, unless otherwise shown on the plans or approved by the City Engineer. The end of a trench may be left open overnight if the entire perimeter of the excavation is fenced, lighted and barricaded with construction equipment and/or Jersey barriers. No excavation, equipment, materials, or other obstruction may impede the flow of traffic without an approved Traffic Control Plan that meets or exceeds current MUTCD standards.
- (H) **Unauthorized Excavation and Pavement Removal.** Unless authorized by the City Engineer, all removed pavement and excavations made beyond the lines and grades shown on the *Construction Drawings* or described in the *Contract Documents* shall be replaced at the Contractor's expense.
- (I) **Unstable Trench Bottom.** Where the excavation is found to consist of muck, organic matter or any other material that is determined, by the City Engineer, to be

- unsuitable for supporting and maintaining the line and grade of the pipe, the trench shall be excavated to an additional depth as agreed upon by the Contractor and Construction Inspector/City Engineer, and replaced with an approved granular stabilization material. Should the Contractor and City fail to reach an agreement as to the depth and/or method of trench foundation stabilization; the developer shall secure the services of a Geotechnical Engineer to assist in determination of an appropriate method for stabilization.
- (J) **Bedding and Shaping Trench Bottom.** Unless otherwise directed, all trenches shall be excavated to at least six (6) inches below the pipe grade and backfilled to grade with approved granular bedding material. The bedding material shall be hand shaped and graded until the trench bottom is uniform and free from rocks, bumps, and depressions. A coupling or bell hole shall be dug at each pipe joint with sufficient length, width and depth to permit assembly of the joint and provide a minimum clearance of two (2) inches between the coupling and the trench bottom. After the pipe is joined, pipe-bedding material shall be placed and tamped under each pipe joint until all voids are filled. Care shall be taken not to displace the pipe from its line and grade.
- (K) **Cutoff Walls.** Cutoff walls shall be installed along every utility line to inhibit the movement of ground water through the screened rock bedding. Cutoff walls shall be five to ten (5 to 10) feet long and consist of native material or imported material that has a permeability rate the same or less than that of the native material. Cutoff walls shall be constructed by discontinuing the installation of bedding and haunching material and installing approved native or imported material. Cutoff walls shall be installed at intervals not exceeding two hundred (200) feet on pressurized lines. On gravity flow lines, cutoff walls shall be installed ten to twenty (10 to 20) feet upstream of each manhole or box.
- (L) **Rock Excavation.** Rock excavation shall consist of the removal of boulders or concrete measuring one-half ($\frac{1}{2}$) cubic yard or more, hard shale, sandstone or other bedrock which, in the opinion of the City Engineer, requires for its removal the continuous use of pneumatic tools or drilling and blasting. Rock excavation shall be in accordance with Section 203 of the current *CDOT Standard Specifications for Road and Bridge Construction*.
- (M) **Stockpiling Excavated Material.** Excavated material shall be piled in accordance with OSHA guidelines in locations that will not endanger the Work, create traffic hazards or obstruct sidewalks and driveways. Storm water runoff from stockpiled materials must be controlled in accordance with Section 9-6 of this manual. Fire hydrants, valve boxes, manholes and other utility access points shall be left unobstructed. Gutters and other watercourses shall not be obstructed unless other satisfactory provisions are made for runoff and street drainage.

All surplus material and excavated material unsuitable for backfilling shall be removed from the site and disposed of in areas secured by the Contractor.

- (N) **Dewatering Trenches.** Trenches shall be kept free of water during pipe laying operations by draining, pumping or other approved methods. The water level shall be maintained at least six (6) inches below the trench bottom throughout the placement of bedding, pipe laying, joining and backfilling operations. The dewatering shall be carried out so that it does not destroy or weaken the strength of the soil under or along the side of the trench. The City Engineer or his representative shall approve the method of disposal of trench water. Watertight plugs shall be installed in the ends of all water and sewer lines when the trench is not being dewatered. The Contractor is responsible for securing a Construction Dewatering Permit from CDPHE.

Surface water from any source shall be prevented from entering the trench excavation.

- (O) **Backfilling Pipe and Structures.** Unless otherwise specified or approved by the City Engineer, all backfill material shall be placed with moisture-density control in accordance with the typical trench detail shown on the *City Standard Drawings*. All backfill material shall be adjusted to optimum moisture plus or minus two percent ($\pm 2\%$) for non-clay soils, and at optimum moisture to plus four percent (+4%) for clay soils, prior to its placement in the trench.

A minimum of twenty-four (24) inches of compacted backfill shall be placed over the top of all polyvinyl chloride (PVC) and polyethylene (PE) pipes before vehicles or heavy equipment are allowed to pass over the pipe. Less cover may be allowed only where *flow-fill* or other approved material is used for the pipe haunching and backfill material. Flow-fill shall meet the requirements of section 9-5-10 of the Concrete Standards, unless approved by the City Engineer.

During initial backfilling, the Contractor shall take all necessary precautions to prevent movement or distortion of the pipe or structure being backfilled. Pipe haunching material shall be placed and compacted in even lifts on both sides of the conduit to six (6) inches above the top of the pipe. Above the bedding and haunching material, earth backfill material shall be placed full width in uniform layers not more than twelve (12) inches thick, or eight (8) inches thick within two (2) feet of existing structures. Each layer shall be compacted to the required density with approved mechanical or hand tamping equipment. Hydro-hammers or other heavy compaction equipment shall not be used unless approved by the City Engineer. No hydro-hammer shall be used for compaction with less than forty-eight (48) inches of cover over the pipe.

It shall be the Contractor's responsibility to make necessary excavations and to provide safe access into the excavations in accordance with OSHA Standards in order to accommodate compaction tests at all locations designated by the authorized Technician.

- (1) **Backfill Testing Requirements:** All backfill shall be frequently tested to ensure that the required density is being attained. For every four hundred (400) linear feet of trench and each branch or section of trench less than four hundred (400) feet in length, at least one (1) compaction test shall be performed for each two (2) foot vertical depth of backfill material placed. The first test shall be taken approximately two (2) feet above the top of pipe and the last test shall be at the pavement subgrade or six (6) inches below the ground surface in unpaved areas. Compaction tests shall be taken at random locations along the trench and wherever poor compaction is suspected. If any portion of the backfill placed fails to meet the minimum density specified, the failing area shall be defined by additional tests, if necessary, and the material in the designated area shall be recompacted to the required density, or removed and replaced at the Contractor's expense.

The frequency of compaction testing may be reduced to one (1) test for every one thousand (1000) feet of trench if full-time inspection is made during the backfilling operation by the Project Engineer or an independent testing laboratory and sufficient initial testing has been performed to demonstrate that the methodology being used achieves the required results. The methodology shall be verified for each soil type or trench condition encountered.

Failed compaction tests shall be immediately reported to the Inspector and the Contractor. A summary report of all compaction test results, including retests of failed tests and a test location map or other approved location format shall be submitted to the Project Engineer and to the Contractor. Compaction test results are required as a basis of acceptance of facilities by the City in accordance with subsection 9-3-7.
 - (2) **Backfilling Concrete Structures:** Concrete structures shall not be backfilled until the concrete and mortar therein has attained a minimum compressive strength of two thousand (2000) psi and can sufficiently support the loads imposed by the backfill. The Contractor is responsible for providing test results verifying that the concrete has reached two thousand (2000) psi compressive strength. Earth backfill shall be placed simultaneously on all sides of the structure in layers approximately twelve (12) inches thick. Each layer shall be compacted to not less than ninety-five percent (95%) of the maximum dry density determined in accordance with AASHTO T-180.
- (P) **Granular Stabilization, Bedding and Haunching Materials.** Granular materials required for stabilization of poor subgrade soils, bedding of pipe and structures, and haunching around pipe shall meet gradation requirements specified in Section 9-2-5 (P) of this manual.

Crushed rock shall be the product of crushing rock and gravel. The portion of the material larger than will pass a three-eighth ($\frac{3}{8}$) inch sieve shall contain at least fifty (50) percent of particles having three or more fractured faces. Not over five percent (5%) shall be pieces that show no fractured faces.

- (Q) **Earth Backfill Material.** Earth backfill material shall consist of approved materials developed from project excavations or imported from another source. To be suitable for backfill, earth material shall be free from muck, frozen lumps, ashes, trash, vegetation and other debris. All excavated materials that, in the opinion of the City Engineer, are unsuitable for use in the backfill shall be removed from the site and disposed of by the Contractor at his expense. The maximum size of rock or clod allowed within six (6) inches of any plastic pipe shall be one (1) inch.
- (1) *Proof Rolling:* The City Engineer or Construction Inspector may require proof rolling of the compacted backfill material to test for deflection or additional consolidation. The Contractor shall furnish a rubber-tired, self-propelled vehicle for proof rolling. Acceptable proof rolling equipment includes a loaded water truck or loaded dump truck. If while proof rolling, any visible deflection or rutting is observed, additional compaction of the backfill will be required.
- (R) **Restoration of Grounds.** The cleanup and restoration of grounds shall be a continuous process from the beginning of construction to final completion of the Work. The Contractor shall keep the work site free from accumulation of debris and waste material caused by his operation. In the case of point-location work to be performed later in the construction process, such as water line tie-ins, the restoration (but not the clean up) of the area adjacent to the point-location may be delayed until the point-location work is performed.
- (1) After the pipeline is backfilled, the area shall be cleaned and restored to the original grade and condition. The cleaning and restoration shall be kept up to no greater than five hundred (500) feet behind the backfill operations.
- (2) All fences, utilities, culverts, ditches, structures, grassed areas and plantings shall be replaced and restored to a condition equal to or better than that at the beginning of construction.
- (3) The restoration of asphalt and concrete surfaces and structures may be performed at the completion of a segment of the project, unless otherwise specified. A segment is defined as one contiguous length of pipe installed.
- (S) **Restoration of Concrete and Pavement Surfaces.** The Contractor shall replace all concrete and pavement surfaces removed or damaged by his operation. All paving, aggregate base course and concrete replacement work shall be in accordance with the *Street System Standards*. Paving and/or patching for an entire project may be performed as a single operation unless otherwise specified.

Prior to paving or patching all edges that have been broken, raveled or otherwise damaged shall be recut to a neat line. Refer to subsection 9-4-3 of the *Street System Standards*.

9-3-6: Sanitary Sewer Pipeline Testing

- (A) **General.** All sanitary sewers shall be tested before final acceptance. The contractor shall notify the City Engineer, and a pre-construction meeting shall be held to determine applicable testing requirements. The Contractor under direct control and observation of the Engineer of Record or an approved independent laboratory, and a representative of the City Engineer shall perform all testing. The Contractor shall furnish all labor, equipment, tools, water and other incidental items required to conduct the tests. Proper cross connection protection shall be used when connecting to the City water system.

- (B) **Re-testing.** If a pipeline fails to meet minimum test requirements, the leak or other deficiency shall be located and repaired at the Contractor's expense. After the repairs or corrections have been made, the pipeline shall be retested. Repairs and retesting shall continue until the test requirements have been met.

- (C) **Leakage Tests.** A leakage test shall be performed on all newly constructed sanitary sewers. The City will determine which test(s) will be made and the Contractor shall furnish all labor, tools and equipment necessary to conduct the test. The allowable types of tests are exfiltration of air and infiltration of air. Other tests may be allowed at the discretion of the City Engineer.

- (D) **Exfiltration of Air Test.** Air testing shall be in accordance with ASTM C-828 or ASTM F1417-92. The ends of the test section shall be sealed at the upper and lower manholes with pneumatic plugs. One of the plugs provided shall have two (2) taps. One (1) tap will be used for introducing air into the pipeline through suitable valves and fittings so that the input air may be regulated. The second tap shall be fitted with valves and fittings to accept a pressure gauge to monitor the internal pressure of the sewer pipe.
 - (1) The pressure gauge shall meet the following minimum specifications:
 - Size.....4½ inch diameter
 - Pressure range0 - 15 psi
 - Figure intervals1-psi increments
 - Smallest intervals0.1 psi
 - Pressure tubeBourdon tube or diaphragm

 - (2) Connect the pressure gauge and air control equipment to the proper fittings and slowly apply air pressure. Pressurize the pipeline to four (4.0) psig and throttle the air supply to maintain the pressure between four and three and one-half (4.0 and 3.5) psig for at least two (2) minutes in order to allow equilibrium between air temperature and pipe walls. During this time check all plugs for leakage. If any plugs are found to leak, bleed off the air, tighten the plugs and re-pressurize the pipeline. After the temperature has stabilized, allow the pressure to decrease to three and one-half (3.5) psig. At three and one-half (3.5) psig begin timing to determine the time required for pressure to drop to two and one-half (2.5) psig. The time, in seconds, for the air pressure to decrease from three and one-half to



two and one-half (3.5 to 2.5) psig shall be greater than the minimum test time shown in the following table.

MINIMUM TEST TIME FOR VARIOUS PIPE SIZES				
Nominal Pipe Size (inches)	Time (sec/100ft)		Nominal Pipe Size (inches)	Time (sec/100ft)
4	18		24	216
6	42		27	252
8	72		30	288
10	90		33	324
12	108		36	360
15	126		39	396
18	144		42	438
21	180			

In areas where the ground water level is above the pipe, the Contractor shall determine the hydrostatic pressure of the ground water above the pipeline and add to all test pressures (1 ft. of water = 0.43 psi). Air testing shall not be accomplished if the groundwater level is greater than ten (10) feet above the sewer line.

- (G) **Infiltration of Air Test.** Manholes will be tested using the negative air pressure test (vacuum) in accordance with ASTM C 1244, or latest edition, for watertightness, and the manhole will be visually inspected after backfilling. Contractor may backfill before testing with the understanding that any repairs will be made from the exterior of the manhole.
- (1) When using ASTM C1244, a vacuum of ten (10) inches Hg is drawn on the manhole after all lift holes are plugged, and pipes entering the manhole are temporarily plugged and securely braced. The time is measured for the vacuum to drop to nine (9) inches Hg. The manhole is acceptable if the measured time meets or exceeds the values presented in Table 1 of ASTM C1244. If the manhole fails the initial test, it shall be repaired by an approved method at contractor expense until a satisfactory test is obtained.
 - (2) Test times for structures other than manholes will be based on the times for manholes of the nearest equivalent volume or as directed by the Engineer.
 - (3) Written verification must be furnished that the following steps are followed:
 - (a) The test method is only to be applied to precast concrete manholes.
 - (b) Stubouts, manhole boots and pipe plugs shall be secured to prevent movement while the vacuum is drawn.
 - (c) If a manhole fails during the test, necessary repairs shall be made and the vacuum test repeated until the manhole passes the test.

- (4) Vacuum Test (ASTM C1244) for Concrete Sewer Manholes. Minimum allowable test times shall be as follows:

MINIMUM TEST TIMES FOR VARIOUS MANHOLE DIAMETERS							
Diameter (In)							
Depth (Ft)	36	48	54	60	66	72	
Time (Sec)							
8 or less	14	20	23	26	29	33	
10	18	25	29	33	36	41	
12	21	30	35	39	43	49	
14	25	35	41	46	51	57	
16	29	40	46	52	58	65	
18	32	45	52	59	65	73	
20	35	50	58	65	72	81	

NOTES:

The test head shall be placed at the top of the manhole in accordance with the manufacturer’s recommendations.

A vacuum of ten (10) inches of mercury shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time shall be measured for the vacuum to drop to nine (9) inches of mercury.

The manhole shall pass if the time for the vacuum reading to drop from ten (10) inches to nine (9) inches of mercury meets or exceeds the values indicated above.

If the manhole fails the initial test, necessary repairs shall be made by an approved method. The manhole shall then be retested until a satisfactory test is obtained.

- (H) **Alignment Testing.** Proper horizontal alignment of all newly constructed sanitary sewer lines shall be verified by lamp testing. If the line does not pass the lamping test or if something other than crushed rock was used for pipe bedding, deflection testing shall be performed on flexible pipe or appropriate repairs shall be made on rigid pipe.

Lamping will be performed on all sanitary sewer pipe by the Engineer. All lines will be flushed at least twenty four (24) hours and no more than forty eight (48) hours prior to lamping. In order to pass the lamping test, no deformations or defects shall be observed in the pipe, the full vertical height of the pipe shall be observed and seven-eighth (7/8) of the pipe circle shall be observed horizontally.

When the City Engineer allows a sewer line to be stubbed out for a future extension without a manhole on the end, the trench shall be backfilled up to the end of the line but the end of the pipe shall remain accessible. The line shall be lamped from the open end of the pipe to the next downstream manhole.

- (I) **Deflection Testing for Flexible Pipe.** The maximum allowable deflection of flexible pipe shall be seven and one-half percent (7½%) of the Base Inside Diameter. The following values from ASTM D-3034 shall apply for SDR 35 PVC sewer pipe:

Nominal Pipe Size (Inches)	Base Inside Diameter (Inches)	Mandrel Diameter (Inches)
6	5.74	5.31
8	7.665	7.09
10	9.563	8.84
12	11.361	10.51
15	13.898	12.86

The deflection test will be performed by pulling a mandrel through the pipe from manhole to manhole.

- (L) **Closed Circuit Television.** The contractor shall notify the City Engineer after sewer main installations for required testing. Subsequent to sewer main installation, required testing, and prior to paving, the City shall conduct random video inspections at no expense to the Contractor on sewer mains installed in street right-of-ways. Significant deficiencies observed during lamping or random video inspection may prompt the City to require more extensive video inspection to be performed at the Contractor’s expense. The Contractor shall, at his expense, remedy all identified deficiencies to the satisfaction of the City Engineer. The Contractor shall, at his expense, camera sections of the line at the City Engineer’s discretion.

9-3-7: Final Inspection and Acceptance

- (A) **General.** City acceptance of all pipelines is required prior to paving.
- (B) **Contractor’s Warranty.** The Contractor shall guarantee his work to be free from defects in materials and workmanship for a period of not less than two (2) years, the initial Acceptance Period. At the end of the two (2) year initial Acceptance period, and at the written request of the Contractor, the City Engineer and the Contractor shall jointly inspect all dedicated public improvements. The City Engineer may request such tests and inspections as deemed necessary, and consistent with these specifications. Any defects in the system resulting from defective materials, poor workmanship or any other cause attributable to the contractors work shall be corrected by the contractor to the satisfaction of the City Engineer at the Contractor’s expense.
- (C) **Inspection Results Submittal and Documentation.** Contractor shall submit to the City satisfactory results of tests (such as pipeline pressure test, leakage tests, disinfection tests, etc.), certified by the Engineer or an approved independent

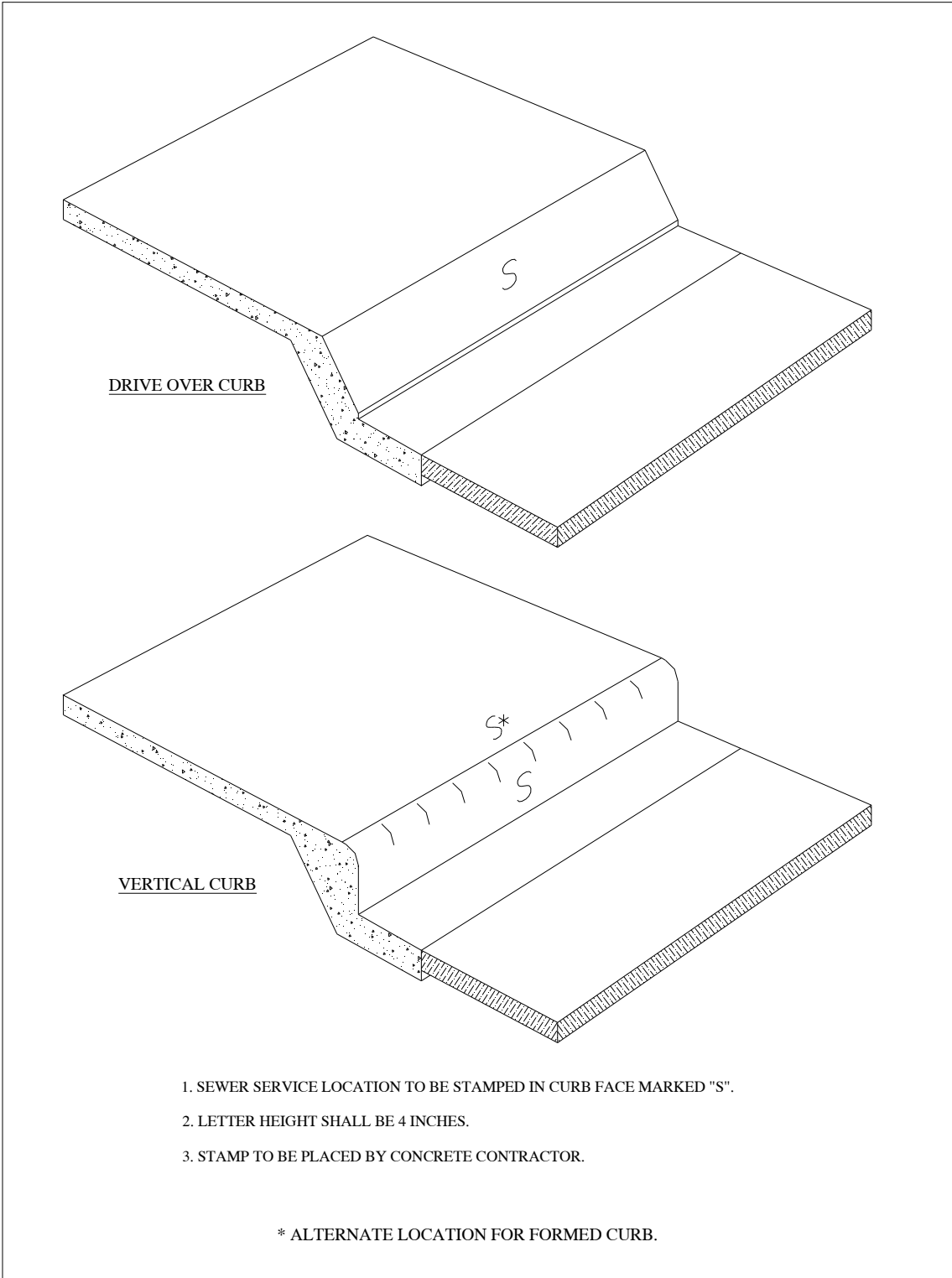
laboratory. For sewer lines, both sanitary and storm, horizontal alignment information shall be required on all service lines and main line fittings. Sewer line "As-Builts" shall also identify material type. Submittal of all quality assurance test results shall comply with Table 1, Required Quality Assurance Testing (see section 9-3-1(C)). The format of required submittals shall be coordinated with the City Engineer.

- (D) **As-Built Drawings.** Contractor shall submit As-Built construction drawings on twenty-four by thirty-six inch (24" x 36") paper. All As-Built drawings shall be certified by a Professional Engineer currently licensed by the State of Colorado. As-Built drawings shall also be submitted as an electronic AutoCAD file in accordance with the Montrose submittal standards.

9-3-8: Sanitary Sewer System Details

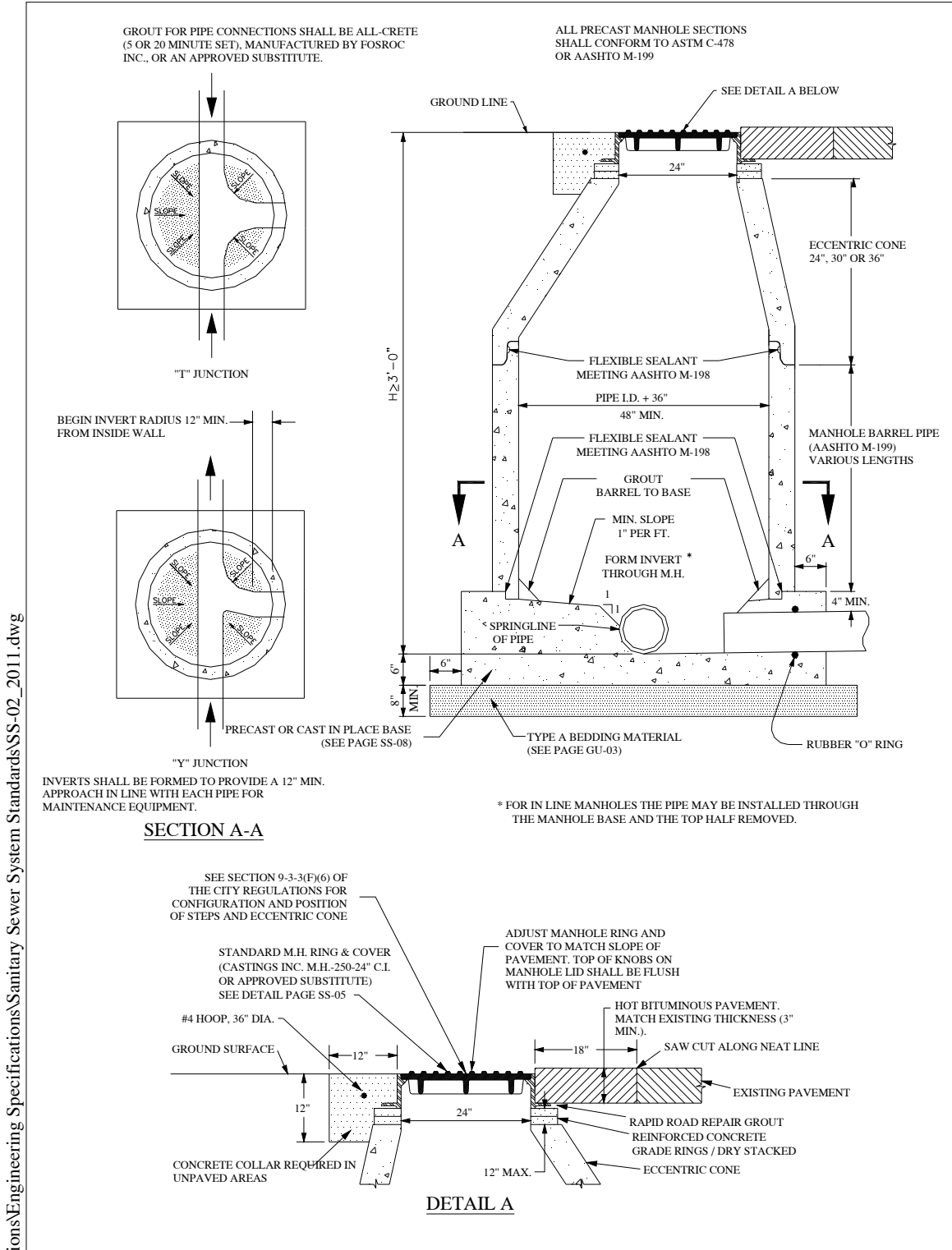
- SS-01 Sidewalk Markings
- SS-02 Standard Manhole
- SS-03 Standard Shallow Manhole
- SS-04 Standard Drop Manhole
- SS-05 Standard Manhole Ring and Cover
- SS-06 Typical Service “Y” Connection
- SS-07 Sewer Service Cleanout Within Right Of Way
- SS-08 Pre-Cast Manhole Base and Manhole Access Location
- SS-09 Round Sampling Manhole
- SS-10 Rectangle Sampling Manhole
- SS-11 750 To 1,250 Gallon Grease Interceptor
- SS-12 1,250 To 3,445 Gallon Grease Interceptor

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SIDEWALK MARKINGS

	<p>ENGINEERING DEPARTMENT</p>	<p>STANDARD SANITARY SEWERS DETAILS</p>	<p>APPROVED: <u>RLW</u> REV: <u>JAN 2011</u> DRAWN BY: <u>RLW</u></p>	<p>PAGE SS-01</p>
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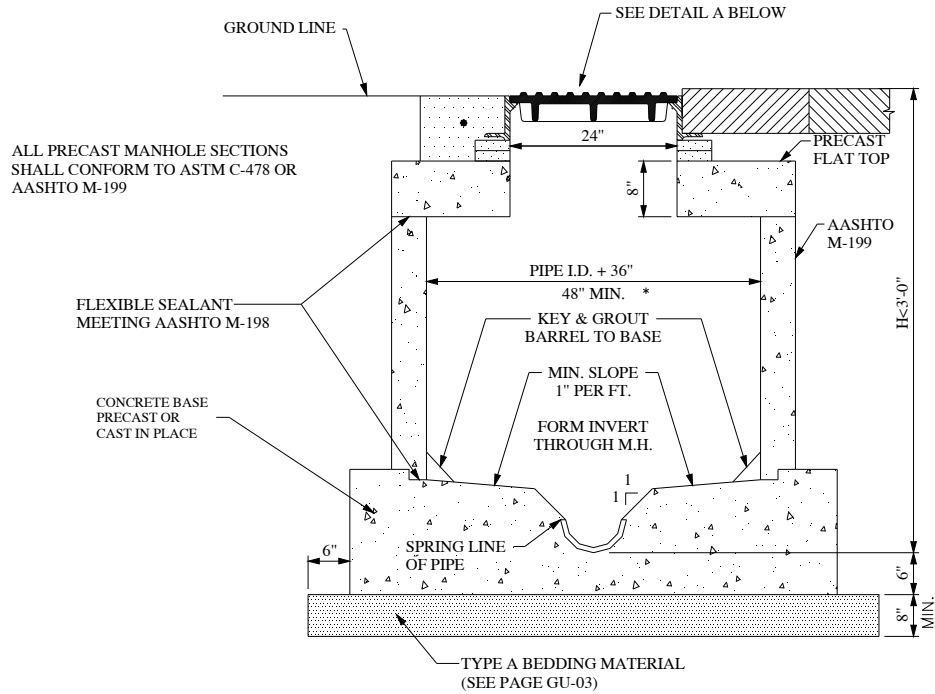


STANDARD MANHOLE

	ENGINEERING DEPARTMENT	STANDARD SANITARY SEWERS DETAILS	APPROVED: <u>RLW</u>	PAGE SS-02
			REV: <u>JAN 2011</u>	
			DRAWN BY: <u>RLW</u>	

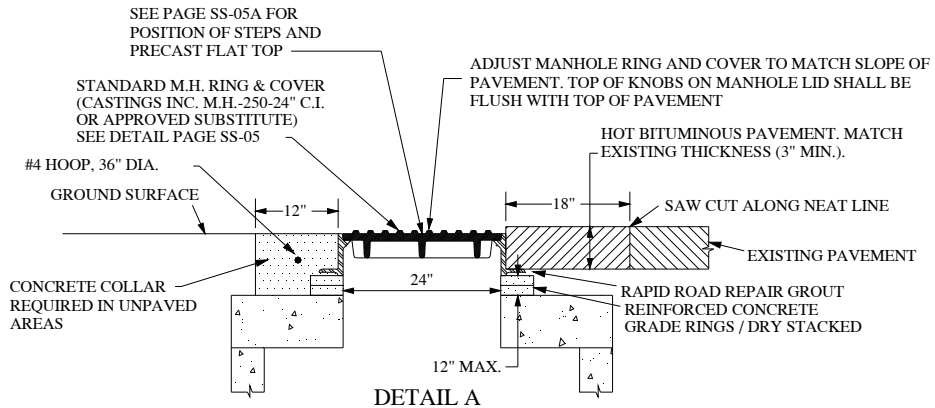
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* FOR IN-LINE MANHOLES WITH A DEFLECTION ANGLE OF 30° OR LESS A 30° BARREL MAY BE USED.

GROUT FOR PIPE CONNECTIONS SHALL BE ALL-CRETE (5 OR 20 MINUTE SET), MANUFACTURED BY FOSROC INC., OR AN APPROVED SUBSTITUTE.



STANDARD SHALLOW MANHOLE

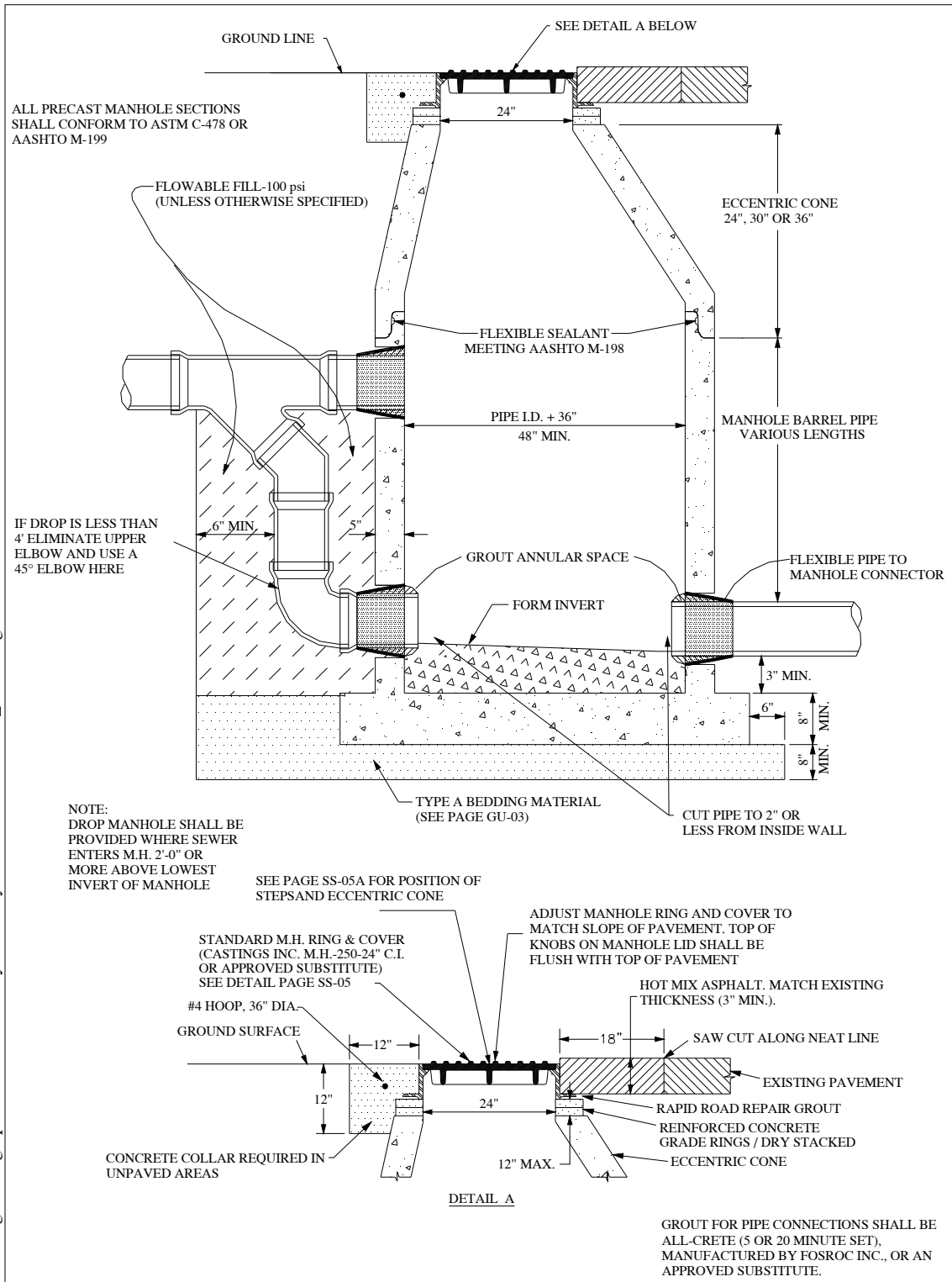


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STANDARD SANITARY SEWERS DETAILS

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 DRAWN BY: RLW

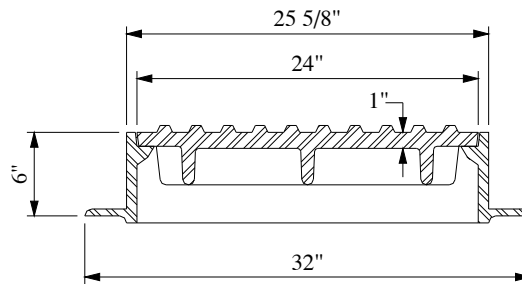
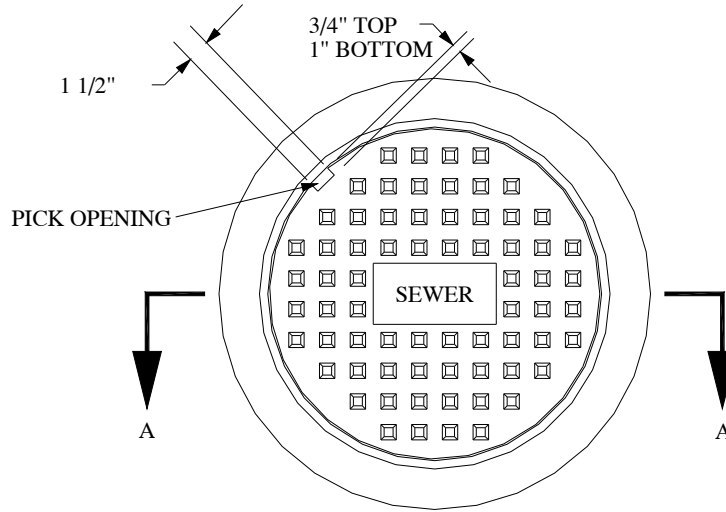
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STANDARD DROP MANHOLE

	<p>ENGINEERING DEPARTMENT</p>	<p>STANDARD SANITARY SEWERS DETAILS</p>	<p>APPROVED: <u>RLW</u> REV: <u>JAN 2011</u> DRAWN BY: <u>RLW</u></p>	<p>PAGE SS-04</p>
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SECTION A-A

IN SIDEWALK USE SMOOTH CASTING-MH-400-24-A OR APPROVED EQUAL

STANDARD MANHOLE RING AND COVER



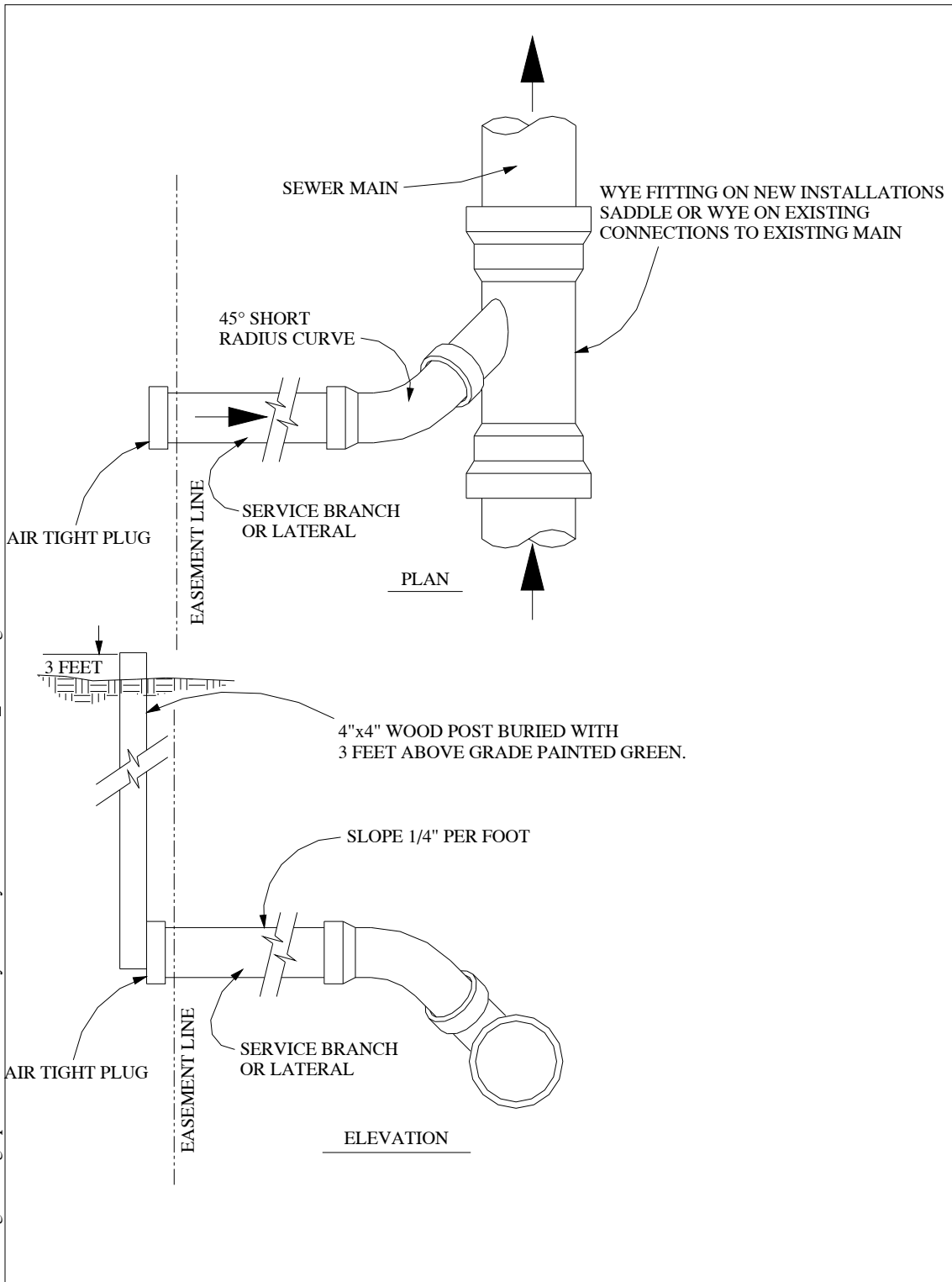
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TYPICAL SERVICE "Y" CONNECTION

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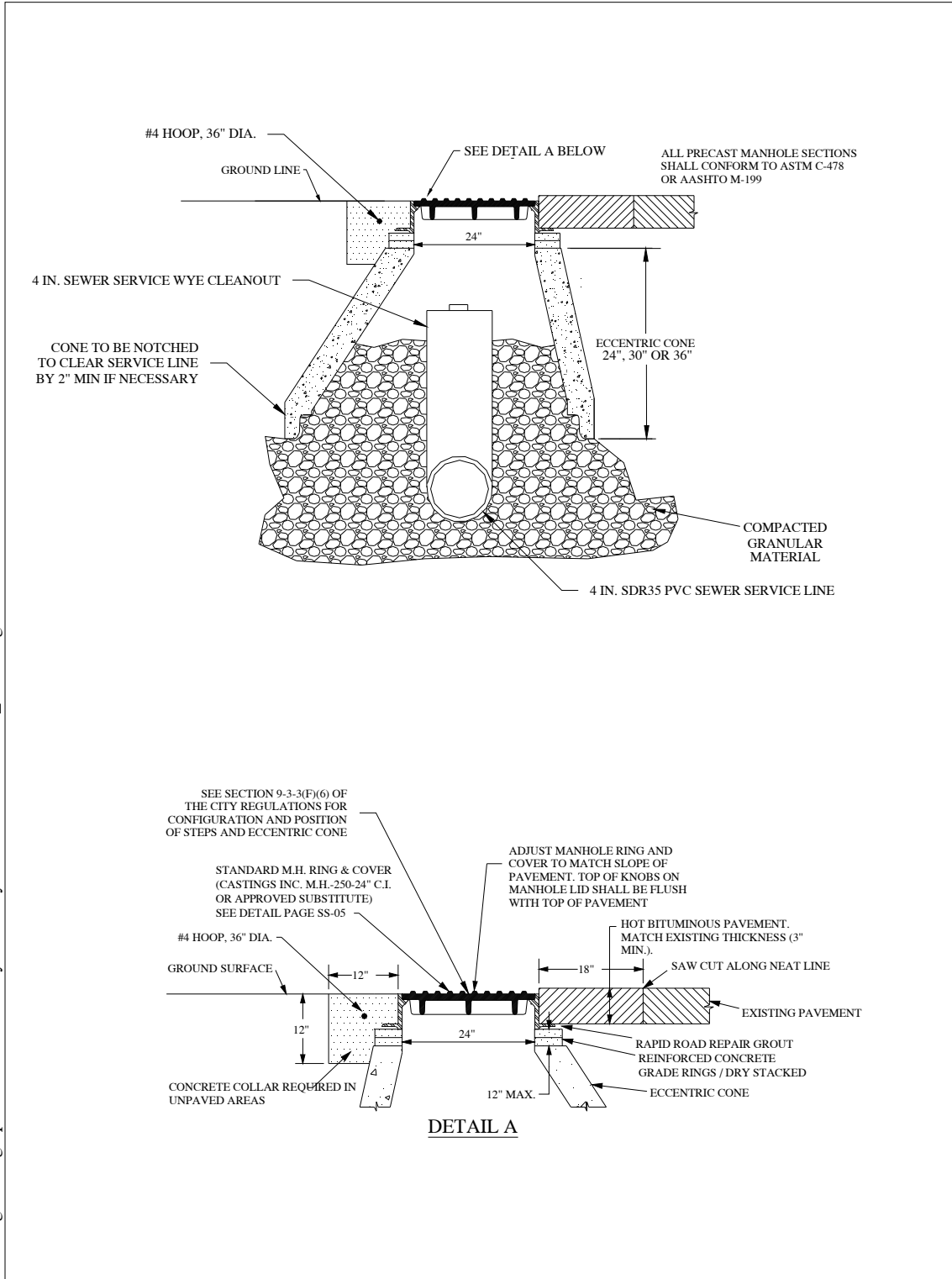


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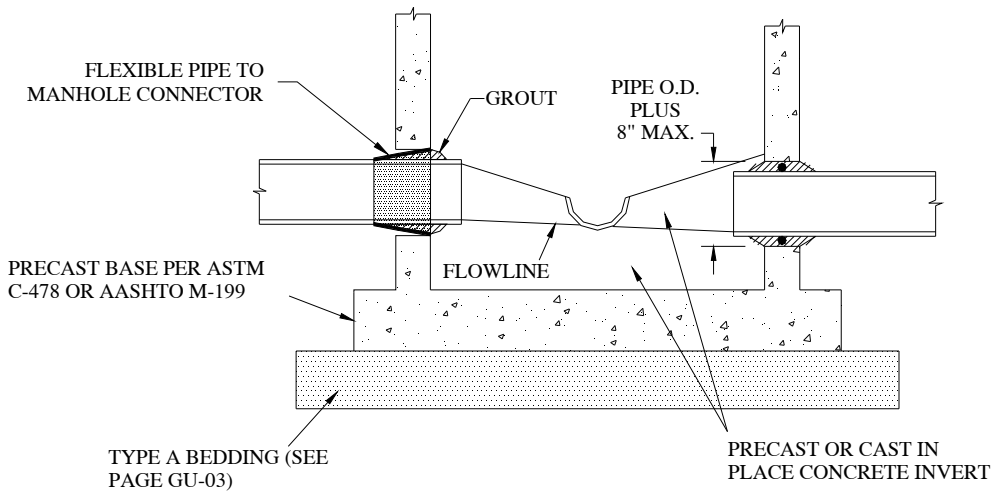


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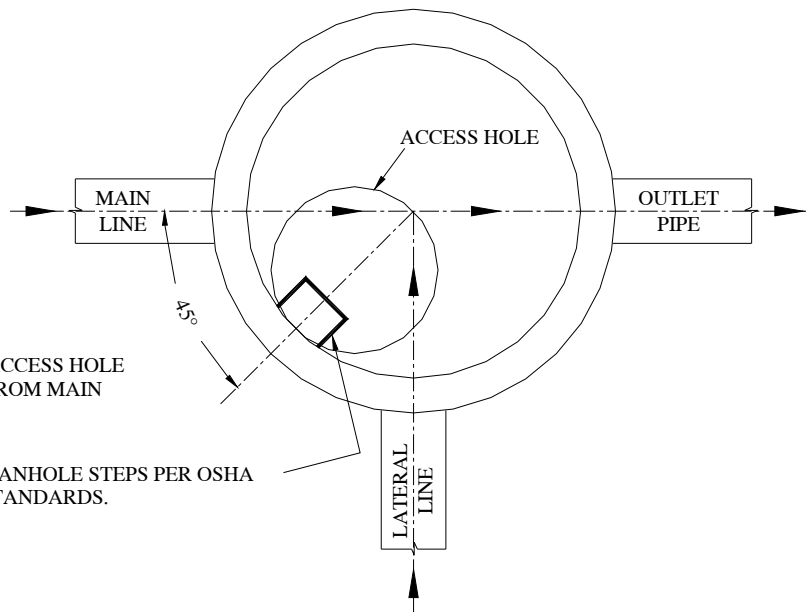
SEWER SERVICE CLEANOUT WITHIN RIGHT OF WAY

	<p>ENGINEERING DEPARTMENT</p>	<p>STANDARD SANITARY SEWERS DETAILS</p>	<p>APPROVED: <u>RLW</u> REV: <u>JAN 2011</u> DRAWN BY: <u>RLW</u></p>	<p>PAGE SS-07</p>
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GROUT FOR PIPE CONNECTIONS SHALL BE ALL-CRETE (5 OR 20 MINUTE SET) MANUFACTURED BY FOSROC INC. OR AN APPROVED SUBSTITUTE.



PRECAST MANHOLE BASE



MANHOLE ACCESS LOCATION

PRECAST MANHOLE BASE AND MANHOLE ACCESS LOCATION



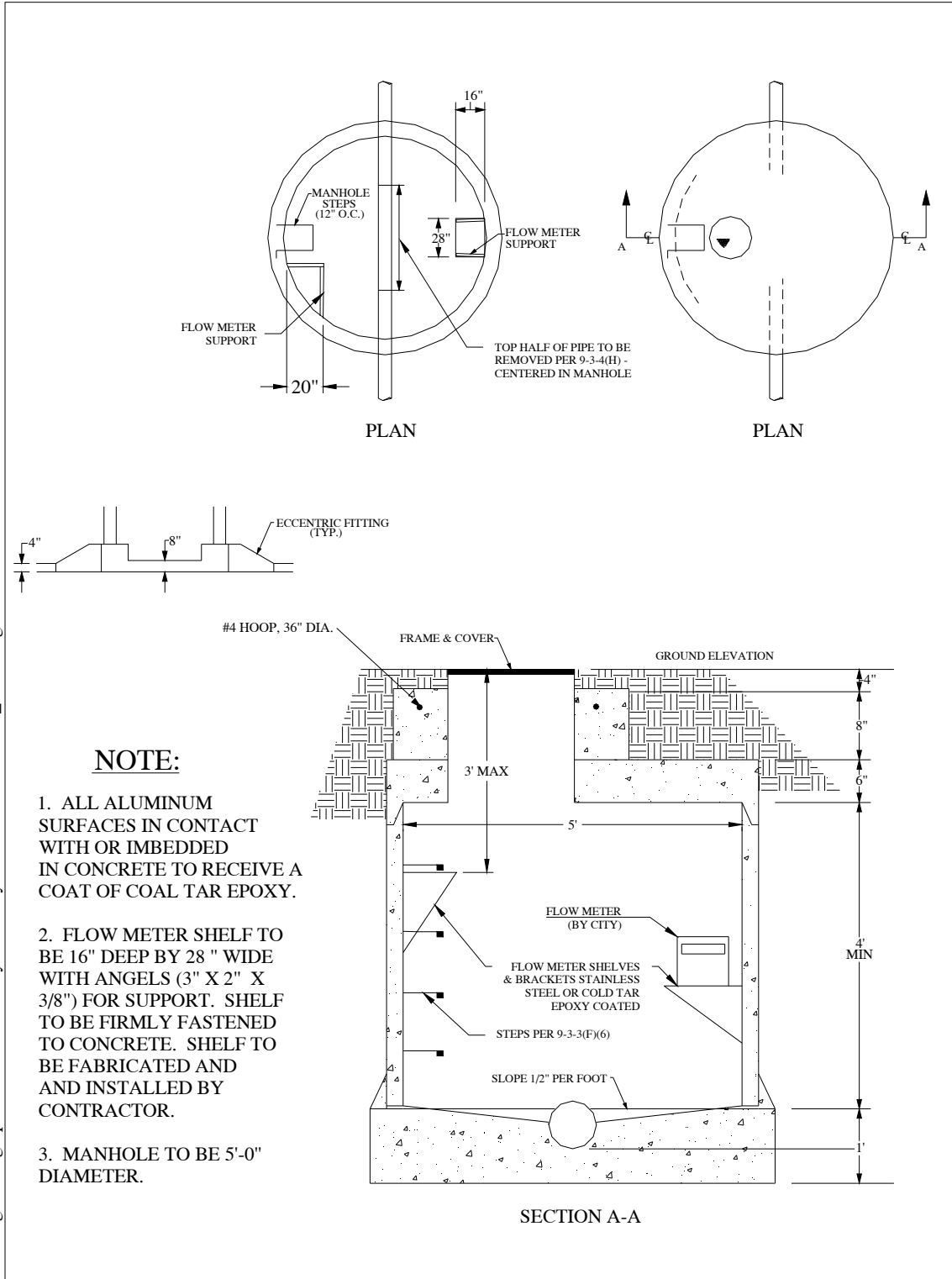
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ROUND SAMPLING MANHOLE



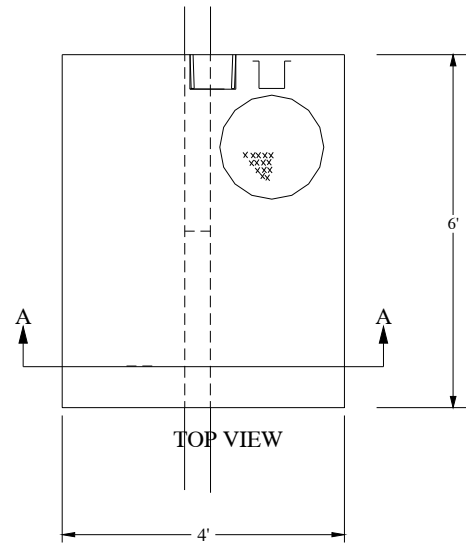
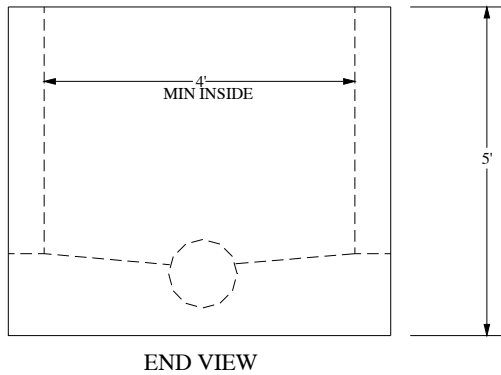
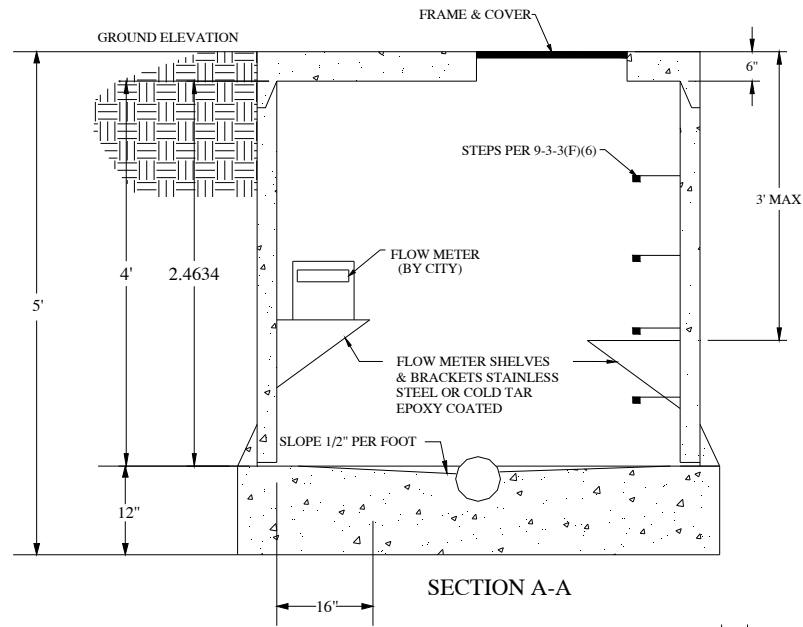
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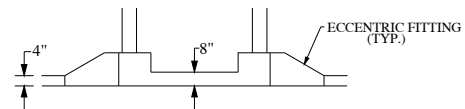
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NOTE:

1. ALL ALUMINUM SURFACES IN CONTACT WITH OR IMBEDDED IN CONCRETE TO RECEIVE A COAT OF COAL TAR EPOXY.
2. FLOW METER SHELF TO BE 16" DEEP BY 28" WIDE WITH ANGLES (3" X 2" X 3/8") FOR SUPPORT. SHELF TO BE FIRMLY FASTENED TO CONCRETE. SHELF TO BE FABRICATED AND INSTALLED BY CONTRACTOR.
3. VAULT TO BE 4' X 6' AND 5' DEEP (MIN).



RECTANGLE SAMPLING MANHOLE



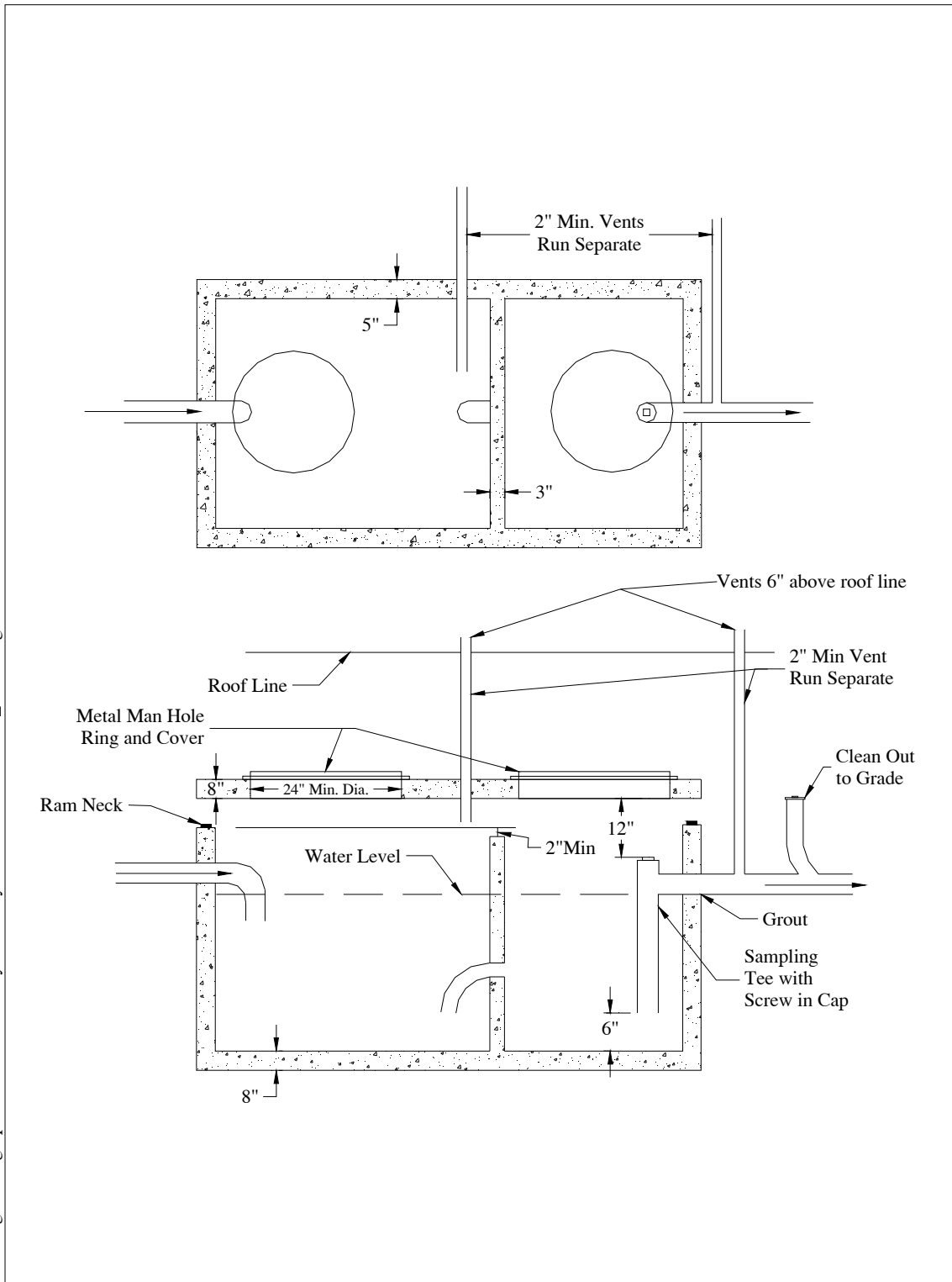
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750 TO 1,250 GALLON GREASE INTERCEPTOR



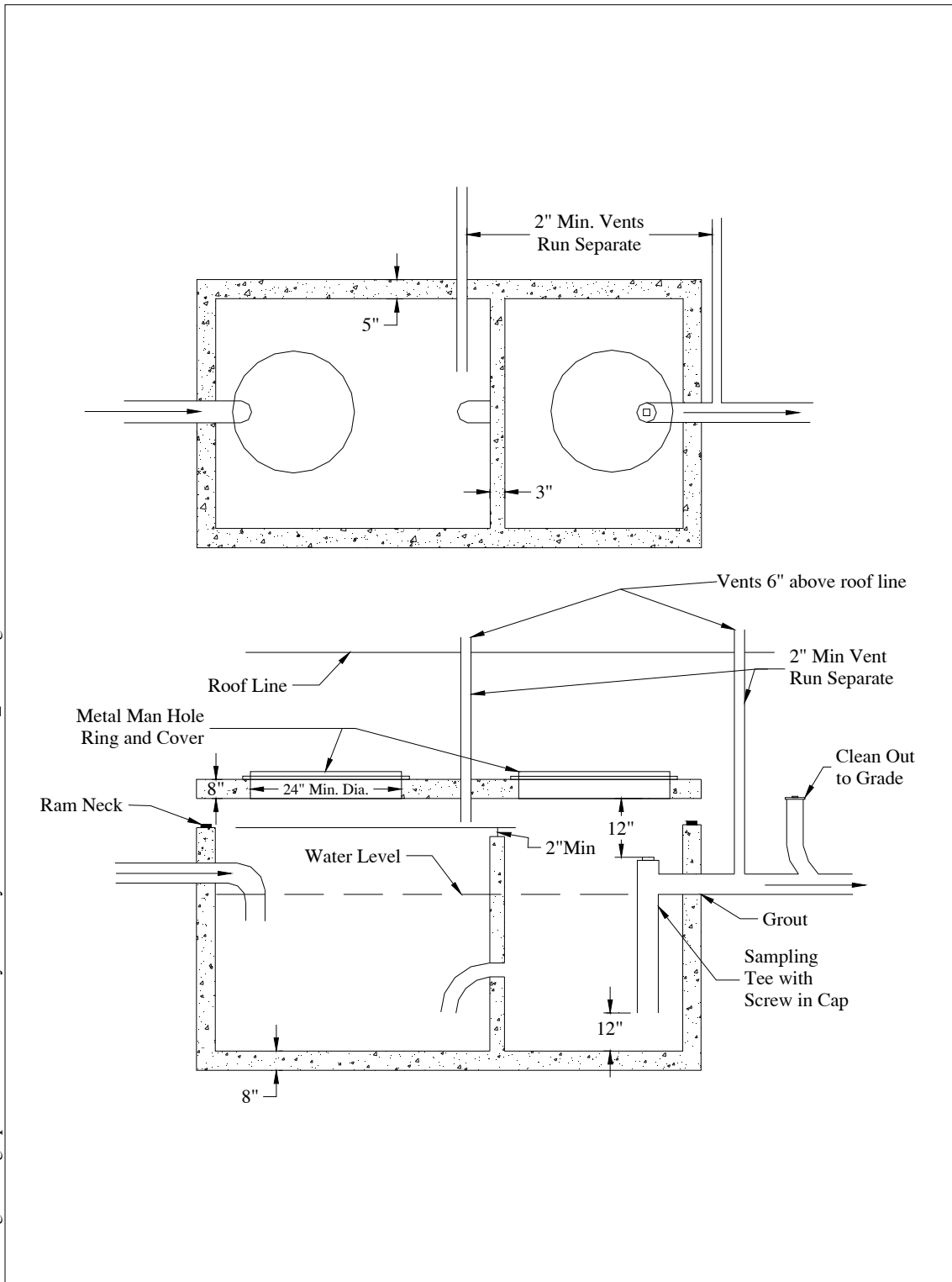
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1,250 TO 3,445 GALLON GREASE INTERCEPTOR



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STANDARD SANITARY
SEWERS DETAILS

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