

ARTICLE II
SANITARY SEWER SYSTEMS

Section 201 General Requirements

- 201.1 All development shall be provided with an approved system for wastewater disposal in accordance with this Article and subsequent sections of this Ordinance.
- 201.2 All sanitary sewer installations, extensions, pump stations, appurtenances, and all collection and treatment systems shall be designed and constructed in accordance with the most current regulations of the Missouri Department of Natural Resources’ rules, regulations, and Statutes of the State of Missouri.

Section 202 Materials

202.1 **Gravity Sewer Pipe:** Gravity Sewer Pipe shall be PVC pipe conforming to the following specifications.

1.1 PVC pipe shall be solid wall meeting the requirements of ASTM D3034, latest revision, with wall thickness SDR35 for sizes 8” thorough 15””; and meeting ASTM F-679 for 18” and larger. Pipe shall be extruded with one end to serve as a spigot end and the other as a bell end, with a gasket groove molded inside for retention of a rubber gasket used in making the joint. Standard laying lengths shall be 12.5’ or 20’.

1.1.1 Drop Impact Test: Pipe shall withstand, without failure at 73°F, an impact of a falling missile (20 pounds Tup A) at the following levels, in accordance with ASTM D2444 latest revision:

Nom. Size in Inches	Ft-Lbs.
8	210
10	220
12	220
15	220

1.1.2 Pipe Stiffness: Minimum pipe stiffness (F/deltSD-y) at 5% deflection shall be 46 PSI for all sizes when tested in accordance with ASTM D2412, latest revision.

1.1.3 Flattening: There shall be no evidence of splitting, cracking, or breaking when a specimen of pipe, six-inches long, is flattened between parallel plates in a suitable press until the distance

between the plates is forty percent of the outside diameter of the pipe. The rate of loading shall be uniform and such that the compression is completed within two to five minutes.

- 1.2 Minimum Pipe Diameter: All gravity sewer mains shall have a minimum diameter of 8-inches.

202.2 Pressure Sewer Pipe: Pipe for pressure sewers shall be either PVC or ductile iron.

- 2.1 PVC pipe for pressure sewer lines shall be solid wall meeting the requirements of ASTM D2241, latest revision, with wall thickness SDR 21 (Class 200). Pipe shall have an integral bell with a locked-in, solid cross section elastomeric gasket that meets the requirements of ASTM F477, latest revision. Provisions must be made for contraction and expansion at each rubber ring bell and spigot joint. Pipe shall be made from clean, virgin, NSF approved PVC material conforming to ASTM D1784, latest revision.

- 2.1.1 SDR 21 pipe shall be suitable for use at maximum hydrostatic pressures of 200 PSI at 73°F.

- 2.1.2 Physical and Chemical Tests: Pipe shall meet the following physical and chemical test requirements. All physical and chemical tests shall be conducted at 73°F ± 3.6°F.

Test	ASTM Ref.	Requirements
Quick Burst Test	D1599	630 PSI applied in 60 to 70 sec.
Sustained Pressure Test	D1598	1000 hrs. @ 420 PSI
Acetone Immersion Test	D2152	No visible spalling or cracking after 20 minutes
Vise Test	--	No splitting or shattering when compressed 60% in 2 to 5 minutes

- 2.2 Ductile iron pipe for pressure sewer lines shall be pressure class 350 and shall conform to the latest revision of ANSI A21.51 - (AWWA C151) Standard for Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand Lined Molds, for Water or Other Liquids. The pipe shall be standard asphaltic varnish coated on the outside. Pipe shall be cement mortar lined in conformance with ANSI A21.4-90 - (AWWA C104) unless specified otherwise.

2.2.1 Joints for ductile iron pipe that is to be buried shall be a push-on type. The push-on type joints consisting of a single neoprene gasket, which are acceptable, are “Tyton” as manufactured and licensed by the U.S. Pipe and Foundry Company; “Fastite” as manufactured and licensed by the American Cast Iron Pipe Company; and “Bell-Tite” as manufactured and licensed by James B. Clow and Son, Inc. All required joint material, including the neoprene gasket and the lubricant, shall be furnished with the pipe.

202.3 **Pressure Sewer Fittings:** Fittings for pressure sewer lines larger than four (4) inches in diameter shall be mechanical joint of either gray iron or ductile iron, and shall conform to the requirements of ANSI/AWWA C110/A21.10-93 or C153/A21.53-94. All fittings shall be coated and lined in the same manner as the pipe. All mechanical fittings shall be pressure class 350 ductile iron. Fittings shall be standard asphaltic varnish coated on the outside. Fittings shall be cement mortar lined in conformance with ANSI A21.4-80 (AWWA C104). Mechanical joint and push-on joint gaskets shall meet all applicable requirements of ANSI 21.11-85 (AWWA C111).

3.1 Fittings for pressure sewer lines four (4) inches in diameter and smaller shall be of the same material as that of pipe.

202.4 **Precast Manholes and Manhole Drops:**

4.1 Materials:

4.1.1 Portland Cement: Shall conform to ASTM C150, latest revision, Type I, II, or V.

4.1.2 Concrete Reinforcement: Shall be reinforcing bars conforming to ASTM 615, Grade 60.

4.1.3 Aggregate: Shall conform to ASTM C33, latest revision, for coarse and fine aggregate.

4.1.4 Mortar: Shall conform to ASTM C270, latest revision, Type M.

4.1.5 Water: Mixing water shall be clean and potable.

4.1.6 Dampproofing: Shall conform to Koppers Specifications for Coal Tar Bitumastic Super Service Black or an approved alternate.

4.1.7 Joint Sealant: Shall meet AASHTO Specification M-198, and shall be suitable for application in vertical and horizontal joints. Sealant shall be as manufactured by Hamilton-Kent, Ram-Nek, or approved equal.

- 4.1.8 Manhole Pipe Connectors: Shall be a resilient connector designed to make a watertight seal between the precast manhole and sewer pipe, conforming to the requirements of ASTM C923, latest revision. Connectors shall be SD-LOK, as manufactured by SD-LOK Products, Inc. or approved equal.
- 4.1.9 Grout: Grout shall be a pre-mixed, packaged, non-ferrous, aggregate non-shrink grout. Grout shall be SEALTIGHT 588 Grout, as produced by W.R.Meadows, or approved equal.
- 4.1.10 Manhole Castings: All castings shall be made of clean, even grain, tough gray cast iron. The casting shall be smooth, true to pattern, and free from projections, sand holes, warp, and other defects that would interfere with the use of, or impair the serviceability of the casting. All castings shall be well cleaned before enamel coating is applied. The iron used for these castings shall conform to ASTM A48, latest revision, for Class 30 gray iron. The “B” test bar (1.2” diameter by 21” long) shall be used to prove the quality of iron used. Manhole frames and covers shall be designed for heavy duty service. Cover shall be solid with two (2) pick holes and the total weight of the unit shall be 400 pounds minimum.
- 4.1.11 Manhole Steps: Manhole steps shall be copolymer polypropylene plastic steps with ½-inch grade 60 steel reinforcement as manufactured by M.A. Industries, Inc., Model PSI-PF, or polyethylene steps with ¾-inch O.D. 6351-T6 aluminum tubing as manufactured by MSU Mississauga Ltd., Model 360, or approved equal.
- 4.1.12 Manhole Drops: Shall be provided for a sewer entering a manhole 24” or more above the manhole invert. Type A drops, constructed of SDR-35 PVC pipe, shall be provided for all drops of two feet up to eight feet. Type B drops, constructed of Class 50 ductile iron pipe, shall be provided for all drops greater than eight feet.
- 4.2 Fabrication and Construction Requirements:
 - 4.2.1 Fabrication and Manufacturing: Precast reinforced concrete manholes shall be manufactured to requirements of ASTM C478, latest revision and shall be of the type, size, and configuration shown on the drawings. Manhole tops shall be of the eccentric type. The minimum allowable wall thickness shall be determined by the manhole depth as below:

Manhole Depth	Minimum Wall Thickness
0 to 16 feet	1/12 of internal diameter
16 feet or greater	1/12 of internal diameter + 1”

Minimum internal diameter of any manhole section shall be 4 feet. Dampproofing shall be factory applied on all interior and exterior surfaces except to the interior surface of the bottom section. Dampproofing shall be field applied to the interior surface of the bottom section after base and fillet have been placed. Dampproofing system shall be Koppers Coal Tar Bitumastic Super Service Black or an approved alternate, applied to manufacturer’s specifications. Two coats, each of minimum 14 mils dry thickness, shall be applied. A 75-volt maximum wet sponge detector shall be employed to check for holidays in the dried finish film. Manhole access opening shall be 22” diameter, minimum.

4.2.2 Construction:

- (a) Joints in the precast concrete manhole shall be set in a pre-molded mastic material or a rubber gasket to produce an absolutely watertight joint under full hydrostatic head conditions.
- (b) Bases shall be 6” thick precast flat bases, with inverts constructed in the field, or shall be a precast bottom with precast integral bottom.
- (c) Precast riser sections shall be set plumb and oriented with manhole steps and access opening to match the detailed drawings designations.
- (d) Inlet and outlet pipes shall extend through the walls of the structures a sufficient distance beyond the outside surface to allow for connections, and shall extend six inches beyond the inside surface of the wall. The new manhole shall be cleaned of silt, debris, or other foreign matter prior to acceptance.
- (e) Openings in manhole sections for inlet and outlet pipes shall be formed at the factory, and shall utilize cast-in-place manhole pipe connector gaskets.
- (f) Invert channels shall be smooth and semi-circular in shape conforming to the inside of the adjacent pipe line sections with change in flow direction made by a smooth curve of as

large a radius as the manhole size will permit, and changes in the size and grade of the channels being made gradually and evenly. Manhole floor shall rise a minimum of 1 inch per foot from side of channel to wall.

- (g) All lifting holes shall be thoroughly wetted and completely filled with non-shrinking grout to form a watertight seal.
- (h) All castings, frames, and covers shall be set true to line and to correct elevation upon a mastic gasket. Frames and covers shall have true common bearing surfaces, such that the covers will seat firmly without rocking or shifting.
- (i) Manholes shall not leak more than 1.14 gallons per day per vertical foot of manhole under a full hydrostatic head.
- (j) The drop pipe in manhole drops shall be constructed using standard pipe sections and fittings to enter at the bottom of the manhole and also continue the incoming line in a straight line to enter the manhole at a higher elevation, all as shown on the detailed drawings.

4.3 Inspection and Rejection: The quality of materials, the process of manufacture, and the finished manhole sections shall be subject to inspection and approval by the City. Manhole sections shall be subject to rejection for failure to conform to any of the specified requirements. In addition, individual sections may be rejected because of any of the following:

- 4.3.1 Fractures or cracks passing through the wall;
- 4.3.2 Defects that indicate imperfect proportioning, mixing, and molding.
- 4.3.3 Surface defects indicating honeycombed or open texture;
- 4.3.4 Damaged or cracked ends where such damage would prevent making a satisfactory joint;
- 4.3.5 Any continuous crack having a surface width of 0.01 inch or more and extending for a length of 4 inches or more.

202.5 Pipe Bedding Material:

- 5.1 Granular Stone: Granular stone pipe bedding material shall be crushed limestone consisting of aggregate particles meeting the requirements of ASTM C-33, latest revision, gradation 67, 1-inch to No. 8 size as follows:

Sieve Size	Percent Passing
1"	100
3/4"	90-100
3/8"	20-55
No. 4	0-10
No. 8	0-5

- 202.6 **Steel Casing Pipe:** Steel pipe for casing at highway and railroad crossings shall conform to AWWA C200-91.

Section 203 Installation Procedures

203.1 Trenching, Bedding, Backfilling, and Compacting:

- 1.1 Materials:

- 1.1.1 Earth Backfill: Earth backfill shall be earth previously excavated from the trench, free from perishable matter, frozen soil, stone over four (4) inches in its largest dimension, and other matter liable to become unstable when saturated with water and compacted.
- 1.1.2 Select Backfill: Where previously excavated earth is determined to be unsuitable for backfill, suitable material from an approved source shall be obtained.

- 1.2 Construction:

- 1.2.1 Trench Excavation (Gravity Sewer Lines):

- (a) All trench excavation shall be made with a sufficient working space to permit the placement, inspection, and completion of all work contemplated in the contract. Excavated material that is unsuitable for backfill, and all boulders exposed by trenching shall be removed from the work area. Trenches shall be excavated in accordance with the standard detail for trench width relative to trench depth.

- (b) Trenches shall be excavated to six inches below established flow lines to provide clearance for the pipe bell and not less than four inches of granular stone bedding material. Should the trench be excavated more than six inches below the flowline, only granular stone bedding material shall be used to establish flow line grade.
- (c) In all cases, trench excavation shall be continuous from the ground surface to the established trench depth. Materials excavated shall be stockpiled at the sides of the trench and within established area limits to minimize inconvenience to the public, and damage to vegetation and structures in the area.
- (d) When unstable ground is encountered, the trenching shall be carried out utilizing trench shoring, bracing, and shields to prevent cave-ins.
- (e) Trench width from six inches below the bottom of the pipe to six inches above the pipe joint shall be held to 24” minimum, or 1.4 times the pipe O.D., plus 12 inches. Trench width above these levels may be wider to accommodate shoring, bracing, and shields, but shall be kept within practical limits.

1.2.2 Trench Excavation (Pressure Sewer Lines):

- (a) Trench Depth: Trenches shall be cut as deep as necessary on either side of natural depressions, ditches, waterways, etc. to provide for not less than 36 inches of cover over the top of the pipe. Depth of cover shall be measured from the outside top of the pipe vertically to the original ground surface or pavement surface. Mounding over the trench to attain the specified cover shall not be permitted. Trenches shall be cut to prevent high spots that could lead to “air binding” of the line. Trenches shall be excavated to four (4) inches below the bottom of the pipe to provide clearance for not less than four (4) inches of pipe bedding material. The maximum degree of deflection, either vertical or horizontal, shall not cause a pipe joint’s annular clearance in the bell to be less than one-fourth (1/4) inch at its closest point. In case the trench be excavated at any place more than four (4) inches below grade, it shall be filled to the design grade with approved bedding material. In all cases, trench excavation shall be continuous from the ground surface to the established trench depth. Gutters and

ditches shall be kept clear, or other satisfactory provisions shall be made to facilitate drainage. Ground adjacent to trench shall be graded to prevent water from flowing into the trench. Provisions shall be made for the continuous flow of all waterways, ditches, drains, or sewers encountered during construction. All ditches and waterways shall be restored to their original conditions as soon as possible.

- (b) Trench Width: The width of the trench, as dug, from the trench bottom to the top of the pipe, shall not exceed the outside diameter of the pipe bell or socket plus 12 inches, or 24 inches, whichever is greater. Trench width above the top of the pipe shall be as required by field conditions to prevent sliding and caving of the excavation.
- 1.3 Sheeting, Shoring, or Bracing: Sheeting, shoring, or bracing shall be placed wherever necessary for the proper preserving of any excavation, embankment, or structure. Where the ground is of such a character or other conditions are such as to render it necessary, the sheeting shall be closely driven and to such depth below the lowest point of the final excavation as may be required. Shore up, protect, and insure from injury all buildings, retaining walls, piers and footings, storm sewers, sanitary sewers, gas lines, water lines, fences, curbs, trees, or other property liable to be injured during the process of the work. Sheeting, shoring, and bracing shall be provided, installed, and maintained to protect the excavation and insure open trench operations.
- 1.4 Placement of Bedding Material:
 - 1.4.1 Granular Stone Pipe Bedding: Granular stone shall be placed in the trench and shaped to provide uniform support for the bottom quadrant of the pipe barrel. The bedding shall be not less than four (4) inches in thickness. Following placement of the pipe, the trench shall be filled with granular stone bedding material to a minimum compacted depth of six (6) inches above the pipe barrel.
- 1.5 Backfilling: Material used for backfilling of trenches shall be free from perishable matter and from other material liable to become unstable when saturated with water after having been compacted. No frozen material shall be used in backfill. Care shall be taken to prevent damage to the pipe and structures. Special precautions shall be taken in backfilling over pipes. No backfill shall be placed over any portion of pipes and/or joints not inspected by the City Engineer. The bedding material shall be brought to a depth of at least six inches over the top of the pipe bell, with this material carefully deposited in uniform layers not exceeding six inches in

depth, and each layer carefully and solidly tamped with mechanical tampers in such a manner as to avoid damage to pipe or disturbing completed work. Unless noted otherwise on the drawings, backfilling for the remainder of the trench shall be previously excavated gravel, sand, or earth, and shall contain no stone over four inches in its largest dimensions. Stones smaller than that size may be used in proportion not exceeding one part of stone and three parts of earth in any place. This backfilling shall be deposited and spread in layers and solidly tamped. Except as specified for roadway crossings, trench backfill shall be compacted to 80 percent of the maximum density at optimum moisture. As the trenches are backfilled, remove all surplus material and regrade the surface, leaving it in good order. The trenches shall be filled to the ground surface elevation which previously existed.

- 1.6 New Manhole Over an Existing Line: Construction of a new manhole over an existing line shall be accomplished by blocking or plugging flow from the first manhole upstream of the proposed manhole location, removing two joints from the existing sewer at the location of the new manhole, installing the new manhole, and replacing the removed joints of sewer pipe. This procedure will enable the new manhole to be fabricated with flexible pipe connector gaskets. Temporary pumping of flow from the plugged upstream manhole to the downstream manhole shall be provided by the Contractor as necessary, to prevent raw sewage discharges.
- 1.7 Connections to Existing Manholes: Existing manholes used for connecting new sewer lines to the existing sewerage system will have the invert chipped out and grouted back with non-shrink grout as required to facilitate the uninterrupted sewage flow from the new connection. All new pipe to existing manhole connections shall be made with flexible connector gaskets, such as INSERTSD-LOK connectors, as manufactured by SD-Lok Products, Inc. Upon completion of the new connection, the entire manhole shall be vacuum tested in accordance with Section 102-3 - TESTING.
- 1.8 Aerial Crossings: If permitted, aerial crossings shall comply in all respects with 10 CSR 20-8.120 (10) of DNR's Design Guide for Waste Treatment Design.

203.2 Installation:

2.1 Pipe Installation:

- 2.1.1 General: Only workers competent at laying pipe shall be employed on this phase of the work, and complete suitable equipment necessary for the execution of same is required. Any incompetency observed must be removed, and where improper

equipment or lack of same appears to be impairing the quality or speed of the work, such adjustment in same shall be made.

- 2.1.2 Handling of Materials: The pipe, fittings and valves shall be placed in the trench with care. Under no circumstances shall pipe or other materials be dropped or dumped into the trench. If plastic pipe is used, the pipe shall be snaked into the trench, either employing the natural snaking tendency of some plastic pipe or the pipe shall be laid from one side to the other on alternate lengths.
- 2.1.3 Pipe Cleaning During Laying Operations: The pipe, if furnished from the factory with dust covers over the ends, shall be examined carefully during laying operations to insure that such covers are not lost inside the pipe. At the termination of pipe laying, the open end of the pipeline shall be closed off by a suitable cover until laying operations are resumed. No pipe shall be placed in the trench unless it is intended to make the joint to the pipeline at that time.
- 2.1.4 Inspection of Materials During Construction: Any materials not meeting the specifications, or obviously faulty material, shall be rejected and removed from the job site.
- 2.1.5 Joining Pipe: In joining sections of pipe, the installer shall use good working practices. All pipe ends shall be cleaned thoroughly inside and out before application of lubricant. The recommendations of the manufacturer of the pipe shall be followed closely in joining this type of pipe. Care shall be taken in lowering pipe into the trench in order that a tensile stress is not created that would cause partial or complete separation of the joints. Concrete thrust blocks shall be installed on pressure sewer line construction at all bends, tees, crosses, and reducers.
- 2.1.6 Breaks in Pipe and Joints: Breaks in the pipe or joints shall be repaired.
- 2.1.7 Slope and Alignment: Gravity sewers shall be laid with uniform slope between manholes. Gravity sewer lines 24 inches in diameter or less shall be laid with straight alignment between manholes. Alignment shall be checked by laser beam or lamping.
- 2.1.8 Bedding of Plastic Pipe: The Contractor shall bed the pipe in accordance with the requirements of Section 203-1, Trenching, Backfilling, and Compacting.

- 2.1.9 Avoidance of Unnecessary Bends: Excessive bends in the alignment of pressure sewer lines will not be permitted. Where obviously required, sweep ells shall be used in making connections between two sections having differing alignment. Standard 90° elbows are not to be used, except in confined locations.
- 2.2 Anchorage of Pressure Sewer Line Bends, Tees, and Plugs: All tees, plugs, caps, and bends exceeding 22-1/2" shall be squarely anchored by suitable thrust concrete backing. Such concrete backing shall be so placed that the pipe or fitting joints will be accessible for repair. The concrete shall be of 1:3:5 mix and shall be placed between solid ground and the fitting to be anchored. The area of the bearing on the pipe and the ground in each instance shall be a minimum of four square feet.
- 2.3 Separation of Sewer and Water Lines:
- 2.3.1 Horizontal Separation: When sanitary sewers are to be laid parallel to existing potable water lines, it will be necessary to maintain at least ten feet horizontal separation between the sewer and water lines. The distance shall be measured between outside edge of lines. In cases where it is not practical to maintain this specified separation, the City may allow installation of a sewer line closer to a water line, provided that the water main is located in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer.
- 2.3.2 Vertical Separation (Crossings): Sewer lines crossing water mains shall be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer. This separation shall be provided whether the water main is above or below the sewer. The crossing shall be constructed such that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to prevent damage to the water main.
- 2.3.3 Special Conditions: When it is impossible to obtain the horizontal and vertical separations specified herein, the sewer shall be designed and constructed equal to water pipe. The sewer pipe shall be pressure tested in accordance with Paragraph 3.6 of Section 203-3 of this specification.
- 2.4 Stream Crossings: Stream crossings with sewer lines requiring special construction shall be installed as shown on the standard details.

203.3 Testing:

3.1 Gravity Sewer Testing:

- 3.1.1 General: All completed gravity sewers shall require pneumatic or hydrostatic testing for the purpose of locating potential infiltration and/or exfiltration within the system. Sewer service lateral lines shall be excluded from testing requirements.
- 3.1.2 Pneumatic Testing Procedure: Performance of low pressure air testing on all sections of completed sewer 8-inch through and including 24-inch diameters, shall be conducted in the presence of the City Engineer. It will be the responsibility of the Contractor to furnish and operate equipment capable of making the required tests. Pneumatic plugs shall be utilized to isolate sewer sections for testing. Plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected. Pneumatic plugs shall resist internal test pressure without requiring external bracing or blocking. All air used shall pass through a single control panel and three individual hoses shall be used for connections from the control panel to 1) pneumatic plugs for inflation; 2) sealed line for introducing the low pressure air; and 3) to the sealed line for continually monitoring the air pressure rise in the sealed line. Equipment shall be Cherne Air-Loc equipment or approved equal. Testing methods and air leakage rates shall conform to ASTM F1417, latest revision, as a minimum. Otherwise, the following procedures shall be followed:
 - 3.1.3 Pipe Above Groundwater Table: All pneumatic plugs shall be seal-tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The sealed pipe shall be pressurized to 5 psig. The plugs shall hold against this pressure without bracing and without movement of the plugs of the pipe. After a manhole reach of pipe has been backfilled and cleaned and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psig greater than the average back pressure of any groundwater that may be over the pipe. At least two minutes shall be allowed for the air pressure to stabilize. After the stabilization period (3.5 psig minimum pressure in the pipe), the air hose from the control panel to the air supply shall be disconnected. The portion of line being tested shall be termed “Acceptable” if the time required in minutes for the pressure to

decrease from 3.5 to 2.5 psig shall not be less than the time shown for the given diameters in the following table:

Pipe Diameter in Inches	Minimum Time (min., sec.)	Max. Length (ft.) for Min. Time	Time (sec.) for Longer Length (L)
4	3:46	597	0.380 L
6	5:40	398	0.854 L
8	7:34	298	1.520 L
10	9:26	239	2.374 L
12	11:20	199	3.418 L
15	14:10	159	5.342 L
18	17:00	133	7.692 L
21	19:50	114	10.470 L
24	22:40	99	13.674 L
27	25:30	88	17.306 L
30	28:20	80	21.366 L
33	31:10	72	25.852 L
36	34:00	66	30.768 L

- 3.1.4 Pipe Below Groundwater Table: In areas where groundwater is known to exist, install a one-half inch diameter capped pipe nipple, approximately 10” long, through the manhole wall on top of one of the sewer lines entering the manhole. This shall be done at the time the sewer line is installed. Immediately prior to the performance of the test, the groundwater shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground to clear it, and then connecting a clear plastic tube to the nipple. The hose shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in this plastic tube. The height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11-1/2 feet, then the added pressure will be 5 psig. This increases the 3.5 psig to 8.5 psig, and the 2.5 psig to 7.5 psig. The allowable drop of one pound and the timing remain the same.)
- 3.1.5 Other Pipe Materials: Low pressure air testing of sewer lines constructed with vitrified clay pipe or reinforced concrete pipe shall be as specified above, except that the minimum specified times required for a 1.0 psig pressure drop shall be as called for in ASTM C828, latest revision (vitrified clay pipe sewer lines), or ASTM C924, latest revision (concrete pipe sewer lines).
- 3.2 Testing of Manholes: Make either hydrostatic or vacuum infiltration/exfiltration tests of all manholes in the presence of the City, to demonstrate that the manholes are free of leaks.

3.2.1 Hydrostatic Testing: Where the top of the sewer is below water level, a one-half inch ($\frac{1}{2}$ ") galvanized pipe nipple is to be cast into each manhole wall and capped on the inside. The pipe nipple is to be located at the top of the inside bore of sewer pipe. All tests are to be conducted in the following manner:

- (a) Test plugs are to be placed in the end of each sewer pipe on the downstream and upstream side of each manhole and inflated to a maximum pressure of 16 psig. Plugs are to be thoroughly blocked to prevent them from blowing out. The manhole is to be filled with water to a level four and one-half feet ($4\frac{1}{2}$ ') above the groundwater level or seven (7') feet above the pipe invert, whichever is higher. Ten minutes shall then be allowed for absorption, after which the water level shall be brought back to the test elevation.
- (b) The specified head shall be maintained on the manhole for a period of eight (8) hours. Sufficient water shall be added to maintain this level. All water added shall be metered to within one-tenth of a gallon and recorded. The maximum allowable leakage shall be as specified herein.

3.2.2 Vacuum Testing: Vacuum testing, performed in accordance with this specification, shall be allowed as a substitute for hydrostatic testing of manholes.

- (a) The vacuum "test head" assembly shall be placed inside the frame of the manhole cover, in order to include in the test the seal between the frame and the manhole cone section, slab, or adjusting rings.
- (b) Plugs shall be placed at least eight inches inside all pipes entering the manhole. Location of plugs shall be such that when inflated, they are past the gasket seal or joint of the manhole and sewer pipe. All plugs shall be braced sufficiently to prevent the plug or pipe from becoming dislodged and drawn into the manhole.
- (c) A vacuum of at least $10\frac{1}{2}$ inches mercury shall be drawn on the manhole. The valve on the vacuum line to the manhole shall be closed, and the vacuum line disconnected. The vacuum within the manhole shall then be adjusted to 10 inches to mercury by opening the vacuum line valve.

- (d) A liquid-filled pressure gauge having a face of 3½ inches and reading from zero to 30 inches of mercury shall be utilized.
- (e) The time for the vacuum reading to drop from 10 inches of mercury to 9 inches of mercury must be equal to or less than the following values in order for the manhole to be considered as passing the vacuum test.

Manhole Depth	Time (minutes)
10 feet or less	2.0
10.1 feet to 15 feet	2.5
15.1 feet to 25 feet	3.0

- (f) If vacuum drops less than one inch mercury within the test time, the manhole is considered acceptable and passes the test. If manhole fails and leaks, the contractor shall make the needed repairs and test again until satisfactory results are obtained. Test may be done before backfilling, but shall be repeated after backfill.
- (g) All safety procedures, placing of plugs, and bracing, labor, and other work required for testing will be the responsibility of the contractor.

3.3 Infiltration/Exfiltration Allowance: Infiltration or exfiltration for sewers 8-inch through 24-inch diameter shall not exceed 200 gallons per inch of pipe diameter per mile per day for any section of sewer. Infiltration or exfiltration for sewers greater than 30-inch diameter shall not exceed 6000 gallons per day per mile of pipe. Infiltration or exfiltration for manholes shall not exceed 1.14 gallons per day per vertical foot of manhole.

3.4 Infiltration/Exfiltration Elimination: The Contractor shall locate all sources of infiltration and exfiltration in the sewer lines, manholes, and appurtenances, and shall correct deficiencies and eliminate infiltration/exfiltration sources in a manner approved by the City Engineer. All sections of sewer line, manholes, and appurtenances shall be re-tested after corrections are finalized.

3.5 Deflection Test: The rules of the Department of Natural Resources, State of Missouri, 10 CSR 20-8.120 (G)5, state that a deflection test shall be performed on all flexible pipe not less than thirty days after the placement of final backfill. The deflection test shall consist of hand-pulling a rigid ball or mandrel through the installed pipe in the presence of the City Engineer. The rigid ball or mandrel shall have a diameter equal to 95 percent of the inside diameter of the pipe. If the rigid ball or mandrel fails

to pull through the pipe, the section being tested fails the test and will be replaced.

3.6 Pressure Sewer Testing:

3.6.1 All piping that is to convey liquid under pressure shall be hydrostatically tested in conformance with Section 4 of ANSI/AWWA C600-93. Testing shall include both a “pressure test” of at least two hours duration for the purpose of blowing defective joints, and a “leakage test” to determine actual loss of water from the system. The use of compressed air for testing pipe shall not be permitted. During the pressure test, the piping shall be subjected to a hydrostatic pressure of 100 psi.

3.6.2 Adequately plug and brace, as necessary, the ends of the pressure sewer, whether they be at the lift station or at the discharge manhole, to allow for the hydrostatic testing.

3.7 Certifications and Acceptance of Tests: All acceptance tests for sewer lines (gravity and pressure) and manholes shall be conducted in the presence of the “certifying engineer” or his representative. The “certifying engineer” is the engineer who will make written certification to both the City and the Missouri Department of Natural Resources that the sewer line has been built in accordance with approved plans and specifications, and that the sewer line has passed all acceptance tests.

203.4 Roadway Surface Replacement:

4.1 All roadway surfaces removed during sewer line construction shall be replaced with the same type of surface as existed prior to construction. The Contractor shall be responsible for determining the nature and thickness of all pavement and surfacings to be cut and replaced, including any base courses. Concrete pavement, asphaltic pavement, macadam pavements, crushed stone, and any type of roadway surface, whether public or private, which is cut or damaged during construction of the project shall be replaced to conform to the lines and grades of the original roadway surface, and shall be of a quality, thickness, and appearance equal to or better than that of the roadway as it existed prior to construction.

4.2 Existing paving shall be cut vertically and horizontally to straight lines. The trench shall be backfilled with granular stone material compacted to 95 percent of maximum density, to an elevation level with the existing riding surface of the roadway. This level shall be maintained by the Contractor until all secondary settling has occurred. Any crushed stone required to maintain the trenches in a suitable condition for traffic during this period shall be furnished at the Contractor’s expense. When the

trench has been properly backfilled and has settled sufficiently to permit final repairs, roadway surfacing shall be applied according to this specification. At the time of final repairs, the Contractor shall remove sufficient material to allow placement of roadway surfacing to the thicknesses specified below.

4.2.1 Granular stone shall meet the gradation requirements specified in Subsection 202.5.

- 4.3 Asphaltic Concrete: Asphaltic concrete roadway surfaces of a thickness greater than 4 inches shall be replaced with a concrete base of 8 inches thickness and 2 inches of asphaltic concrete. Edges of the existing pavement at the trench shall be trimmed vertically to produce a neat even edge. The base surface and vertical edge shall be sprayed with a prime coat of Grade RC-250 liquid asphalt heated to no less than 130°F, at a rate of 0.15 gallons per square yard. This primer shall be applied only when the base and existing pavement are free of moisture. The asphaltic concrete shall be hot mixed in an approved plant and delivered to the work area in dump trucks at a minimum temperature of 275°F. The asphaltic concrete shall be placed and then rolled while hot with an approved five ton steel wheel roller to the same thickness as the existing pavement. In no case shall the total compacted thickness of a layer be less than two inches or greater than four inches. No traffic shall be permitted on the finished pavement until it has cooled to atmospheric temperature. Concrete used for base beneath asphalt shall have a minimum 28-day compressive strength 3000 psi.
- 4.4 Crushed Stone: Trenching along or across unpaved roadways, including county roads, and city streets, as well as dirt, or gravel shoulders of paved streets, roads, or highways, shall be backfilled with granular stone material in compliance with these specifications. The trench shall be backfilled to a level with the existing riding surface of the roadway. When the trench has been properly backfilled and has settled sufficiently to permit final repairs, the backfill shall be removed as necessary for crushed stone surfacing. The crushed stone shall be rolled and thoroughly compacted in layers to a minimum finished thickness of 6 inches.
- 4.5 Concrete: Concrete surfaces, including private drives, shall be replaced with concrete surfacing equal to the thickness of existing pavement, plus a minimum of 2 inches. Concrete shall have a minimum 28-day compressive strength of 3000 psi.

- 4.6 Chip and Seal Asphalt Paving: The area to be repaired shall be bladed to eliminate minor depressions and humps. Following the blading operation, the surface shall be thoroughly cleaned and swept to remove all mud, matted earth, dust, and other foreign material. A prime coat of liquid asphalt shall be applied at the rate of 0.30 gallons per square yard at a minimum temperature of 120°F for asphalt grade CRS-2. On the primed base, a course of aggregate shall be spread at the rate of twenty-five (25) pounds per square yard. This stone shall be roller compacted from sides to center with a steel wheeled roller weighing a minimum of five tons. Immediately following the compaction of the first course of asphalt and aggregate, a second course, identical to the first shall be applied. The finish surface shall be swept to remove any loose stones. No traffic shall be allowed on the finished surface until it has cooled to atmospheric temperature.

203.5 Clean-up:

- 5.1 After completion of any portion of work, the construction area shall be cleaned of all surplus material, earth, rubbish, etc. and left in as near the original state as possible. All ditches and drainage shall be restored to their original condition.
- 5.2 All grassed areas shall be seeded, fertilized, and mulched as required to restore the area to a condition equal to that which existed prior to construction.

203.6 Highway and Railroad Crossings: Where designated on the approved design drawings, underground highway and railroad crossings shall be installed. Such installations shall be accomplished by tunneling, boring, or jacking methods. Each method shall provide for removal of earth and rock encountered during installation of the carrier and casing pipes. Where jacking or tunneling are utilized, the annular space between the casing and earth shall be pressure grouted with neat cement grout.

- 6.1 Highway crossings shall be made in strict compliance with Missouri Department of Transportation requirements. No highway crossings shall be installed without the Contractor first obtaining all necessary permits from the Missouri Department of Transportation.
- 6.2 Railroad crossings shall be made in strict compliance with railroad company requirements. No railroad crossings shall be made without the Contractor first obtaining all necessary permits from the railroad company.

- 6.3 The Contractor shall insure that traffic interruptions are minimized during the underground excavation operations. After the operation is completed, the Contractor shall slide the sewer pipe in place. After the pipe is in place, the annular space between the casing and carrier pipe shall be backfilled with sand, pea gravel, or by spacers approved for use in bracing the carrier pipe against uplift. Once the carrier pipe has been fixed, the annular space at each end of the casing pipe shall be sealed with sand bags or approved casing seals.
- 6.4 The Contractor shall take precautions to insure that the sewer pipe is on line and grade following the installation operation.