IOWA WASTEWATER FACILITIES DESIGN STANDARDS

CHAPTER 12

Iowa Standards for Sewer Systems

12.1 GENERAL

12.1.1 Applicability

This chapter is applicable to construction, installation or modifications of any disposal system required to obtain a construction permit from this Department under Iowa Code 455B.183 and rule 567 IAC 64.2.

See Section 11.1.1 of Chapter 11 for exceptions.

12.1.2 Variances [Paragraph 567 IAC 64.2(9)"c"]

Variances shall meet the requirements of Section 14.1.2 of these standards.

12.1.3 Explanation of Terms

12.1.3.1 Standard Required

The terms "shall" or "must" are used in these standards when it is required that the standard be used. Other terms such as "should" indicate desirable procedures or methods which should be considered but will not be required.

12.1.3.2 Definitions

a. Lateral - A sewer that discharges into a submain or other sewer and has no other common sewer tributary to it.

b. Submain - A sewer into which the wastewater from two or more lateral sewers is discharged and which discharges into a main or trunk.

c. Main - The principal sewer to which two or more submains are tributary; also called trunk sewer.

d. Interceptor - A sewer used to transport the flows from two or more main (trunk) sewers to a central point for treatment and discharge.

12.1.4 Scope of Standard

This chapter shall apply to all sanitary sewers conveying raw wastewater required to obtain a permit to construct in accordance with Section 12.1.1.

12.2 DESIGN PERIOD

In general, sewer system design shall consider the estimated ultimate tributary population, except in considering parts of the system that can be readily increased in capacity. Similarly, consideration shall be given to the maximum anticipated capacity of institutions, industrial parks, etc. Laterals and submains shall be designed for estimated ultimate development. The design of trunks (mains) and interceptors shall take into consideration a reasonable planning period (50 years) and cost effectiveness. When the project does not provide for the ultimate capacity, a report detailing a plan for providing the ultimate capacity shall be developed.

12.3 MINIMUM BASIS OF DESIGN

12.3.1 Sewer Design Capacity

Maximum hourly residential flow, additional maximum wastewater flow from non-residential municipal, commercial and industrial facilities, inflow, infiltration, and sewage pumping station capacity shall be considered in determining the required capacities of sanitary sewers.

12.3.2 Maximum Hourly Residential Flow

The maximum hourly residential flow shall be determined using one hundred gallons per capita per day (gpcd) multiplied by the peaking factor found in Appendix 12-A. The 100 gpcd value, when used in conjunction with the peaking factor, is intended to cover normal extraneous flows for new sewers and new service connections built with modern construction techniques serving households with typical per capita wastewater flow rates. Additional extraneous flow allowances may be warranted where high groundwater levels, significant inflow sources or higher than average per capita wastewater flow rates are anticipated to occur over the design life of the sewer.

If the sewer is to serve existing development infiltration and inflow contributions from upstream sewers and service connections shall be evaluated and the design flow adjusted accordingly.

12.3.3 Minimum Design Equivalents

Type of development

a. single family - 3-3.5 units/acre, 3 people/unit, or 10 people/acre

b. multi-family (medium density - 4.5 units/acre, 3 people/unit, or 15 people/acre

c. multi-family (high density) - 6-12 units/acre, 2.5 people/unit, or 30 people/acre

d. commercial - maximum hourly flow of 5,000 gpd/acre

e. industrial - maximum hourly flow of 10,000 gpd/acre

The minimum design equivalents for commercial and industrial development are expected peak flow rates for new sewers built with modern construction techniques where the specific types of commercial establishments or industrial facilities are unknown. Lower design values may be approved for proposed developments where specific types of establishments or industries are planned and adequate justification is provided for alternative equivalents.

12.3.4 Carrying Capacity of Pipe

Pipe sizes 15” and smaller shall carry the design flow at a depth of no more than $^{2}/_{3}$ of the pipe diameter. Larger pipe sizes shall carry the design flow at a depth of no more than ¾ of the pipe diameter.

12.4 MATERIALS

12.4.1 Material Selection

Pipe and joint materials shall be adapted to local conditions, including but not limited to the character of industrial wastes, possibility of septicity, soil and groundwater characteristics, exceptionally heavy external loadings, abrasion and corrosion.

All sewers shall be designed to prevent damage from superimposed live, dead and frost induced loads. Soil conditions, bedding materials, potential groundwater levels and fluctuations, and the width and depth of the trench shall be considered. Where necessary, special pipe and joint materials, bedding or installation methods shall be used to withstand potential superimposed loading, loss of trench wall stability, and soil or groundwater contamination.

Materials used shall be designed to minimize infiltration and prevent the entrance of roots throughout the life of the system.

12.4.2 Material Standards

Standards shall be as listed below for the respective materials.

a.

Rigid and Ductile Iron Pipes	Material Spec.	Joint Spec.
Clay	ASTM C700	ASTM C425
Non-Reinforced Concrete	ASTM C14	ASTM C443
Reinforced Concrete	ASTM C76	ASTM C443
	ASTM C655	
Ductile Iron	ASTM A746	ASTM A746
	AWWA C151	AWWA C111

b.

Plastic Pipes	Material Spec.	Joint Spec.
Solid Wall PVC	ASTM D3034 (SDR $\leq$ 35)	ASTM D3212
	ASTM F679	
Open Profile PVC	ASTM F794	ASTM D3212
Closed Profile PVC	ASTM F1803	ASTM D3212
Corrugated PVC	ASTM F949	ASTM D3212
		ASTM D2855
Polyethylene	ASTM D2239	ASTM D3261
	ASTM D3035	

c.

Composite Pipes	Material Spec.	Joint Spec.
ABS and PVC Composite	ASTM D2680	ASTM D2680

d. Sewers Constructed of Water Main Materials

All sewers constructed of water main materials shall be a minimum of 150 psi pressure rated and conform to applicable requirements of Iowa Administrative Code Chapter 567 IAC 43.

e. Other Materials

All other sewer pipe and joint materials shall conform with the appropriate ANSI, AWWA or ASTM specifications. For new pipe or joint materials for which ANSI, AWWA or ASTM standards have not been established, the design engineer shall provide complete specifications developed on the basis of criteria adequately documented and certified in writing by the pipe manufacturer to be satisfactory for the application.

12.5 DETAILS OF DESIGN

12.5.1 Diameter

No public gravity sanitary sewer conveying raw wastewater shall be less than eight inches in diameter, with the following exception.

For unsewered communities, six-inch diameter sewers may be used for laterals and submains, provided the six-inch sewers have sufficient hydraulic capacity.

12.5.2 Depth

Sewers should be sufficiently deep so as to receive sewage from basements and to prevent freezing. Precautions such as insulation and increased slope shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

12.5.3 Slope

All sewers shall be designed and constructed to give average velocities when flowing full of not less than 2.0 feet per second based on Kutter's formula using an "n" value of 0.013. The following are the minimum slopes which shall be provided.

Sewer Size	Minimum Slope (ft./100 ft.)
8"	0.400
10"	0.280
12"	0.220
15"	0.150
18"	0.120
21"	0.100
24"	0.080
27"	0.067
30"	0.058
36"	0.046
39”	0.041
42”	0.037

Sewers 48 inches or larger should be designed and constructed to give average velocities when flowing full of not less than 3.0 feet per second based on Kutter's formula using an "n" value of 0.013.

Self-cleansing velocities necessary for transport of particles, initial and ultimate flow rate variations and recurrence intervals, wastewater constituents and particle sizes, anticipated maintenance requirements and sewer cleaning capabilities of the operating authority should all be considered in determining minimum sewer slopes. Calculated slopes associated with self-cleansing velocities should be based on a regularly recurring peak flow, which will be less than the design peak flow used to determine required pipe capacity.

Full-flow velocities of not less than 1.5 feet per second may be accepted for deep or continuous rock excavation, when a lift station can be eliminated or where elevations are fixed such that meeting the minimum slope requirement would require deepening extensive sections of the existing sewer system. In such instances, the design engineer must submit a present worth comparison of all available alternatives demonstrating a minimum cost ratio of 5 to 1. Estimated costs shall be based on alternatives designed to meet not more than the minimum standards of the Department over a common design period not to exceed 50 years.

The slope shall be the maximum feasible where calculated full-flow velocities are less than 2.0 feet per second. Increased maintenance requirements due to lesser velocities shall be considered. Oversizing of sewers will not be approved to justify using flatter slopes where a smaller pipe diameter can accommodate the design flow at the proposed slope based on Kutter's formula using an "n" value of 0.013 and the requirements of Section 12.3.4.

The following exceptions to the above requirements in this section shall apply for unsewered communities only.

A minimum velocity of 2.0 feet per second when flowing full should be maintained in all sewer mains. However, in specific cases where savings in sewer costs are possible or a lift station could be eliminated, a minimum sewer velocity of 1.5 feet per second when flowing full using an "n" value of 0.013 will be permitted. Minimum slopes for 8" sewers flowing full at 2.0 feet per second and 1.5 feet per second shall be 0.40 ft./100 ft. and 0.22 ft./100 ft. Minimum slopes for 6" sewers flowing full at 2.0 feet per second and 1.5 feet per second shall be 0.60 ft./100 ft. and 0.34, ft./100 ft. In cases where a minimum sewer design velocity of 1.5 feet per second is used, the operating authority of the sewer system will be required to give written assurance to the Department that any additional sewer maintenance required by reduced slopes and velocities will be provided.

12.5.4 Horizontal Alignment

Sewers 24 inches or less shall be laid with straight alignment between manholes.

Curvilinear alignment of sewers larger than 24 inches may be considered provided ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves which start and end at manholes. When curvilinear sewers are proposed, the minimum slopes required by Section 12.5.3 must be increased accordingly to provide average full flow velocities equivalent to sewers with straight alignment.

12.5.5 Changes in Pipe Size

When a smaller sewer joins a larger receiving sewer, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

Sewer extensions shall be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole constructed in accordance with Section 12.5.7 with special consideration of an appropriate flow channel to minimize turbulence when there is a change in sewer size. The Department may require a schedule for construction of future downstream sewer relief.

12.5.6 High Velocity and Steep Slope Protection

Where velocities greater than 15 feet per second are attained, special provisions shall be made to protect against displacement by erosion and impact.

Sewers on 20 percent slopes or greater shall be anchored securely with concrete, or equal, anchors spaced as follows:

a. Not over 36 feet center to center on grades of 20 percent up to 35 percent;

b. Not over 24 feet center to center on grades of 35 percent up to 50 percent; and

c. Not over 16 feet center to center on grades of 50 percent or greater.

12.5.7 Manholes

12.5.7.1 Location

a. Manholes shall be installed:

1. at the end of each sewer line;
2. at all changes in pipe size, grade or alignment except for curvilinear sewers constructed in accordance with Section 12.5.4;
3. at all sewer pipe intersections;
4. at intervals not exceeding 400 feet for sewers 15 inches or less or at intervals not exceeding 500 feet for sewers 16 inches to 30 inches.

b. Spacing of manholes up to 600 feet for sewers 30 inches or less or greater spacing for sewers larger than 30 inches may be approved if the operating authority submits written assurance that it has access to cleaning equipment adequate for such spacing.

c. Cleanouts may be permitted in place of manholes at the end of lines. Terminal cleanouts shall be constructed so that flexible cleaning equipment can be passed through them. Cleanout lids should be bolted down to prevent entry of foreign objects. If the sewer is ever extended, the cleanout must be removed and a manhole constructed at that point if the maximum distance between manholes has been reached. When the distance between a terminal cleanout and the nearest downstream manhole exceeds 150 feet, the operating authority will be required to submit written assurance that it has access to cleaning equipment adequate for such spacing.

[LWB1]12.5.7.2 Drop Type

A drop pipe should be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition.

Outside drop connections shall be encased in concrete or other material that will prevent displacement that would result from the backfilling operation in the vicinity of the manhole. Designs incorporating outside drop connections should consider extension of the drop pipe to the ground surface with a suitable cover or other provisions that will facilitate cleaning of the drop pipe. Inside drop connections shall be secured to the interior of the manhole wall and provide adequate access for cleaning the drop.

12.5.7.3 Diameter

The minimum diameter of manholes shall be 48 inches. The minimum diameter of manhole openings shall be 24 inches. Larger diameters should be considered for manholes including an inside drop connection.

12.5.7.4 Watertightness

Manholes shall be pre-cast or poured in place concrete. Manhole lift holes, grade adjustment rings, pre-cast section joints and any additional areas potentially subject to infiltration shall be sealed watertight.

Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.

12.5.7.5 Frame and Cover Assembly

Manhole covers shall be non-vented; however, covers with pickholes are acceptable. Frame and cover assemblies shall be of adequate strength to withstand anticipated live loads.

Watertight cover assemblies shall be required wherever the manhole tops may be flooded by street runoff or high water. Bolt-down cover assemblies shall be required on manholes subject to inundation on a floodplain or displacement by sewer surcharging. Locked manhole covers should be considered in locations where unauthorized access or vandalism may be a problem.

12.5.7.6 Flow Channel

Flow channels through manholes should be made to conform as closely as possible in shape and slope to that of the connecting sewers. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not obstruct maintenance, inspection or flow in the sewers.

When curved flow channels are specified in manholes, including branch inlets, minimum slopes indicated in Section 12.5.3 should be increased to maintain acceptable velocities.

12.5.7.7 Bench

A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than ½ inch per foot. For new manholes, no lateral sewer, service connection, or drop manhole pipe shall discharge onto the surface of the bench.

12.5.8 Protection of Water Supplies

12.5.8.1 Cross Connections

There shall be no physical connection between a public or private potable water supply system and a sewer, or appurtenance thereto, which would permit the passage of any wastewater or polluted water into the potable water supply. No water pipe shall pass through or come into contact with any part of a sewer manhole.

12.5.8.2 Wells and Below-Ground Storage Facilities

Gravity sewers constructed of standard sewer materials shall not be laid within 75 feet of a public well or 50 feet of a private well or below-ground level finished water storage facility. Gravity sewers constructed of water main materials shall not be laid within 25 feet of a well or below-ground level finished water storage facility. Sewer force mains constructed of water main materials shall not be laid within 75 feet of a public well, within 50 feet of a below-ground finished water storage facility, or within 25 feet of a private well. Force mains constructed of other materials shall not be laid within 400 feet of a public well, within 50 feet of a below-ground finished water storage facility, or within 50 feet of a private well.

12.5.8.3 Horizontal Separation of Gravity Sewers from Water Mains

Gravity sewers shall be separated from water mains by a horizontal distance of at least 10 feet edge to edge. Where such spacing is not feasible, a lesser distance may be considered provided that:

a. the top of the sewer is at least 18 inches below the bottom of the water main, the sewer is placed in a separate trench or the water main is located on a bench of undisturbed earth, and a minimum horizontal separation of 3 feet is maintained, or

b. the sewer main is constructed of water main materials and a minimum horizontal separation of 2 feet from the water main is provided.

The separation distance between the sewer and water main shall be the maximum feasible in all cases.

12.5.8.4 Separation of Sewer Force Mains from Water Mains

Sewer force mains and water mains shall be separated by a horizontal distance of at least 10 feet edge to edge. Where such spacing is not feasible, a lesser distance may be considered provided that the force main is constructed of water main materials and a minimum horizontal separation of 4 feet from the water main is provided.

The separation distance between the force main and water main shall be the maximum feasible in all cases.

12.5.8.5 Separation of Sewer and Water Main Crossovers

Vertical separation of sanitary sewers crossing under any water main should be at least 18 inches when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches below a water main or 18 inches above a water main. The separation distance shall be the maximum feasible in all cases.

Where the sewer crosses over or less than 18 inches below a water main one full length of sewer pipe of water main material shall be located so both joints are as far as possible from the water main. The sewer and water pipes must be adequately supported and have watertight joints. A low permeability soil shall be used for backfill material within 10 feet of the point of crossing.

12.5.8.6 Separation of Sanitary Manholes from Water Mains

A minimum horizontal separation of three feet shall be maintained.

12.5.8.7 Exceptions

Should physical conditions exist such that exceptions to Sections 12.5.8.3, 12.5.8.4, 12.5.8.5 or 12.5.8.6 of this standard are necessary, the design engineer must detail how the sewer and water main are to be engineered to provide protection equal to that required by these sections.

12.5.9 Connection of Dissimilar Pipe

Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials. The leakage limitations on these joints shall be in accordance with Section 12.7.

12.5.10 Inverted Siphons

Use of inverted siphons is discouraged where initial average flows will not be sufficient to secure adequate velocities to prevent deposition of suspended solids and where other practical alternatives exist. Siphons shall have not less than 2 barrels, each with a minimum pipe size of 6 inches and shall be provided with necessary appurtenances for convenient flushing and maintenance; the manholes shall have adequate clearance for cleaning equipment; and in general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3.0 feet per second for design average flows. The inlet and outlet details shall be arranged so that the normal flow is diverted to 1 barrel, and so that either barrel may be cut out of service for cleaning. The vertical alignment should permit cleaning and maintenance.

12.5.11 Sewer Crossing Under a Waterway

The top of all sewers entering or crossing streams shall be at a depth below the natural bottom of the stream bed sufficient to protect the line. One foot is required where the sewer is located in rock or cased and three feet is required in other material. In major streams, more than three feet may be required.

In paved channels, the top of the sewer line should be placed below the bottom of the channel pavement. Sewer structures and appurtenances shall be so located that they do not interfere with the free discharge of flood flows of the stream. Sewers located along streams shall be located outside of the stream bed.

Sewers entering or crossing streams shall be constructed of ductile iron pipe with mechanical joints or shall be so otherwise constructed that they will remain water tight and free from changes in alignment or grade. Sewer systems shall be designed to minimize the number of stream crossings. The stream crossings shall be designed to cross the stream as nearly perpendicular to the stream flow as possible. Construction methods that will minimize siltation shall be employed. Material used to backfill the trench shall be stone, course aggregate, washed gravel, or other materials which will not cause siltation. Upon completion of construction, the stream shall be returned as near as possible to its original condition. The stream banks shall be seeded and planted, or other methods employed to prevent erosion. The design engineer shall include in the project specifications the method or methods to be employed in the construction of sewers in or near streams to provide adequate control of siltation.

12.5.12 Aerial Crossings

Support shall be provided at all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning and settlement.

Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.

For aerial stream crossings the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the 50 year flood. Greater elevations may be required.

12.5.13 Storm Sewer Crossings

Adequate support shall be provided where sanitary sewers cross storm sewers. A minimum vertical clearance of 6 inches should be provided. Special structural support should be considered if there is less than 18 inches of clearance.

12.6 DETAILS OF CONSTRUCTION

12.6.1 Excavation

12.6.1.1 Trench Bottom

The trench shall be excavated to line and grade. Bell holes shall be the minimum size that will permit construction of satisfactory joints and ensure uniform bearing of the barrel on the trench bottom, while avoiding bearing on the bells. If the material encountered at the bottom of the trench is not satisfactory for bedding pipe, the unsatisfactory material shall be removed and replaced by material that will give proper support and compaction.

12.6.1.2 Trench Width

The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.

12.6.1.3 Rock Removal

Ledge rock, boulders and large stones shall be removed to provide a minimum clearance of four inches below and on each side of all pipe.

12.6.1.4 Dewatering

All water entering the excavations or other parts of the work shall be removed until all the work has been completed. No sanitary sewer shall be used for the disposal of trench water, unless specifically approved by the engineer and then only if the trench water does not ultimately arrive at existing pumping or sewage treatment facilities.

12.6.2 Bedding, Haunching and Initial Backfill

12.6.2.1 Rigid Pipe

Bedding Classes A, B, C, or crushed stone as described in ASTM C12 shall be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

12.6.2.2 Ductile Iron Pipe

Embedment materials for bedding and initial backfill as described in ASTM A746 for Type 1 through Type 5 laying conditions shall be used for ductile iron pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

12.6.2.3 Plastic Pipe

Embedment materials for bedding, haunching and initial backfill, Classes I, II, or III, as described in ASTM D2321 shall be used and carefully compacted for all plastic pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

12.6.2.4 Composite Pipe

Except as described in ASTM D2680, the bedding, haunching and initial backfill requirements for composite pipe shall be the same as for plastic pipe.

12.6.3 Installation

12.6.3.1 Rigid Pipe

Installation procedures as described in ASTM C12 shall be used for all rigid pipe provided the proper strength of pipe is used.

12.6.3.2 Ductile Iron Pipe

Installation procedures as described in ASTM A746 for Type 1 through Type 5 laying conditions and applicable installation procedures as described in ANSI/AWWA C600 shall be used for ductile iron pipe provided the proper strength of pipe is used.

12.6.3.3 Plastic Pipe

Installation procedures as described in ASTM D2321 shall be used for all plastic pipe provided the proper strength pipe is used.

12.6.3.4 Composite Pipe

Installation procedures for composite pipe shall be the same as for plastic pipe except as specified in ASTM D2680.

12.6.4 Final Backfill

Final backfill shall be of suitable material removed from excavation except where other suitable material is specified. Debris, frozen materials, large clods or stones, organic matter, or other unstable materials shall not be used for backfill within 2 feet of the top of the pipe.

Final backfill shall be placed in such a manner as not to disturb the alignment of the pipe.

12.6.5 Alternative Installation Methods (Trenchless Technologies)

Alternative installation methods may be considered where minimal surface disturbance is desirable or where significant cost savings can be realized using trenchless construction or pipe renewal technologies. Where trenchless installation methods are proposed, grade control including maximum specified elevation tolerances shall be sufficient to meet the requirements of Section 12.5.3.

For new construction subsurface conditions shall be adequately characterized and verified along the bore path. The proper strength pipe and joining system shall be used to withstand anticipated installation and in situ loads, based on the installation method, soil type(s) encountered, potential groundwater conditions and, for pipe renewal methods, the structural condition of the existing pipe. The possibility of prism loading on the pipe shall be considered where live loads, fluctuating groundwater levels, unconsolidated soils or other conditions may cause borehole collapse during the design life of the sewer.

For flexible pipe, the design engineer shall consider the ability of the selected pipe material and pipe wall thickness to maintain long-term ring deflections within ASTM or the pipe manufacturer's recommended design deflection limits under all anticipated loads using the pipe material 50-year modulus. All plastic pipes installed using trenchless methods shall meet the requirements of Section 12.7.1.

12.7 TESTING

12.7.1 Deflection Test

Deflection tests shall be performed on all plastic and composite pipes. The deflection test shall be conducted after the final backfill has been in place at least 30 days.

No pipe shall exceed a deflection of 5%.

If the deflection test is to be run using a rigid ball or mandrel, it shall have a diameter not less than 95% of the base inside diameter or average inside diameter of the pipe depending on which is specified in the ASTM specification, including the appendix, to which the pipe is manufactured. The tests shall be performed without mechanical pulling devices.

12.7.2 Allowable Leakage

Leakage tests shall be specified and may include appropriate hydrostatic or air pressure testing. The testing methods selected should take into consideration the range in groundwater elevations during the test and anticipated during the life of the sewer. The maximum allowable infiltration or exfiltration as determined by hydrostatic testing for any new gravity sewer section, including all manholes, is 100 gallons per inch of diameter per mile of pipe per day. Manholes may be tested separately.

12.7.3 Leakage Tests

12.7.3.1 Line Infiltration Test Using a Weir

The crown of the pipe shall be covered with not less than two feet of water at the highest point in the section tested. The test head shall be maintained for not less than 24 hours before a leakage measurement is made.

The infiltration should be measured by means of a V-notch weir located in the downstream manhole. All service connections and stubs shall be capped or plugged to prevent the entrance of ground water into the line at these connections.

12.7.3.2 Line Exfiltration Test

The inlet of the upstream manhole and test section outlet shall be closed with watertight bulkheads. Then the sewer and the upstream manhole shall be filled with water until the elevation of water in the upstream manhole is two feet higher than the top of the pipe in the line being tested, or two feet above the existing ground water in the trench, whichever is the higher elevation. The exfiltration will be measured by determining the amount of water required to maintain the initial water elevation for one hour from the start of the test. If the average head above the section being tested exceeds two feet, then allowable leakage can be increased by 5% for each additional foot of head. This test is preferable for dry areas where ground water head over the pipe does not exist at the time of the test.

12.7.3.3 Line Air Pressure Test

Air testing, at minimum, shall conform to the test procedures described in ASTM C828 for clay pipe, ASTM C1214 for concrete pipe and ASTM F1417 for plastic, composite and ductile iron pipes.

12.7.3.4 Manhole Exfiltration Test

The inlet and outlet of the manhole shall be plugged and the manhole filled to at least the depth that is used in testing the line. Allow the water to stand one hour and refill to the original elevation. After a specific time, usually 15 minutes to 1 hour, record the difference in elevation and convert into volume lost per unit time through manhole leakage.

To get actual line exfiltration subtract manhole loss from loss determined during line exfiltration test.

12.7.3.5 Manhole Air Test

Air testing shall conform to the test procedures described in ASTM C1244.

12.7.3.6 Exceptions

Replacement of existing sewers which have service connections may be exempted from the leakage testing requirements

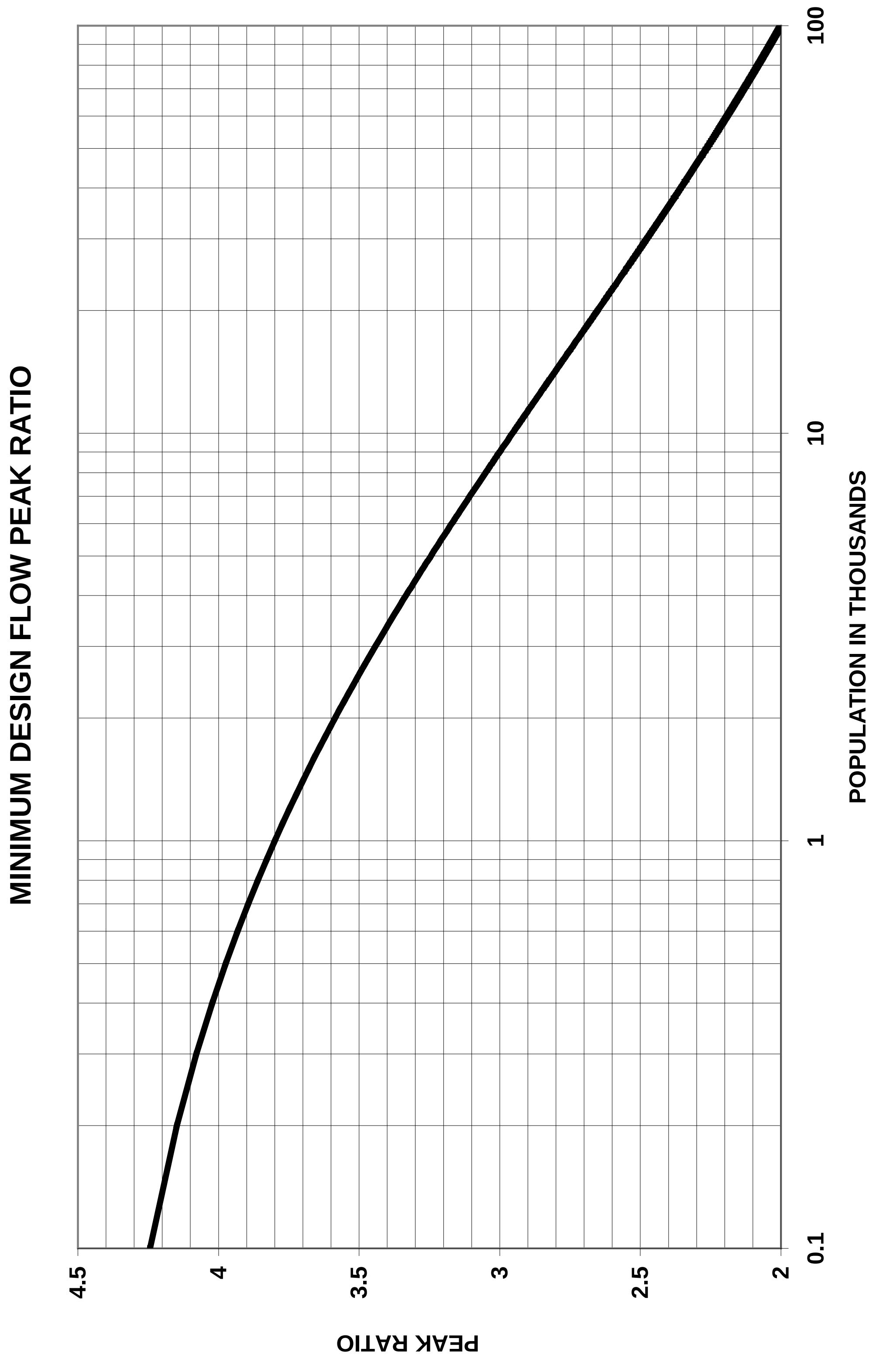
12.7.4 Alignment Test

Sewers shall be checked for alignment by either using a laser beam or lamping. The light should be visible through the section of pipe lamped. The results of the alignment test shall be evaluated by the design engineer.

12.7.5 Video Inspection

Video inspection of all new and rehabilitated sewers after installation is recommended.

APPENDIX 12-A: PEAK RATIO



Curve Equation: Peak Ratio = [(18 + $P^{0.5}$) / (4 + $P^{0.5}$)] where P = population in thousands

Source: Fair, G.M. and Geyer, J.C. "Water Supply and Wastewater Disposal"
1st Ed., John Wiley & Sons, Inc., New York (1954), p. 136

APPENDIX 12-B: Kutter's Formula

$$V = \left[\frac{\frac{1.811}{n} + 41.66 + \frac{0.00281}{S}}{1 + \frac{n}{\sqrt{R}}\left(41.66 + \frac{0.00281}{S}\right)} \right] \sqrt{RS}$$

V = pipe velocity, feet per second
n = coefficient of roughness
S = slope, (unitless, e.g., ft/ft)
R = hydraulic radius, feet