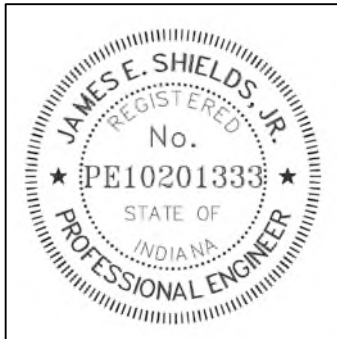




Aqua Indiana State Standards

Sanitary Sewer Construction

January 2021



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Revision Schedule		
No.	Description	Date
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FOREWORD

The “Aqua Indiana State Standards” for Aqua Indiana and its subsidiaries (the Utility) have been prepared to set forth Aqua Indiana’s minimum criteria for construction within the Utility’s limits.

All construction projects which are connected to the Utility system shall conform to these standards. Construction drawings and specifications must be approved by the Utility and a written permit obtained for sewer extensions in accordance with existing ordinances before construction begins. In addition, sanitary sewer projects must be submitted to the Indiana Department of Environmental Management (IDEM) for approval and issuance of a construction permit. Developers may not submit projects to IDEM until the Utility issues a wasteload allocation and approval of plans.

Construction observation will be performed by the Utility. A minimum of 48 hours’ notice shall be given prior to starting construction.

These standards were prepared with the intent of obtaining the highest quality of construction possible, consistent with accepted industry practices and specifications. As new materials become available and acceptable, the standards may be revised and updated.

Critical Design Criteria for Sanitary Sewer Construction:

1. All sanitary sewers shall comply with the latest edition of the “GLUMRB (Great Lakes Upper Mississippi River Board) Recommended Standards for Wastewater Facilities”.
2. State Utility Engineer will make the determination as to the need for improvements to downstream sanitary sewer facilities. Early coordination is recommended to eliminate delays during design.
3. State Utility Engineer will make final determinations as to the ability to reasonably comply with these Design Specifications.
4. These Design Specifications are intended to define the design requirements of sanitary sewer facilities which are constructed and operated under typical conditions in Aqua Indiana service areas. Depending on field conditions and the composition and characteristics of the sanitary sewer flow, different or unusual conditions may occur which cannot be anticipated in a document of this nature. Consequently, the State Utility Engineer may impose additional or special design requirements under such circumstances.
5. Aqua Indiana will not accept gravity sewers designed or installed below minimum slope as specified in Section 33.41 (Recommended Minimum Slopes) of Recommended Standards for Wastewater Facilities “Ten States Standards” (most recent Edition) and/or 327 IAC Article 3, whichever is more restrictive. It is strongly recommended that gravity sewers be designed at slopes greater than the minimum regulatory requirements.
6. All new commercial or industrial entities, which either generate and/or waste oil, grease or the by-products thereto, shall construct a 1,000-gallon (minimum) grease trap. The design engineer shall submit detailed calculations for size justification of said trap to Aqua. Calculations shall be accompanied with references, specifically denoting origin of sizing/calculation method.
7. Toilets, urinals, sinks, showers, and other similar fixtures shall not waste through the grease interceptor. All other waste shall enter through the grease trap interceptor, through the inlet pipe only.
8. The grease interceptor and grease trap shall be designed such that it is easily accessible, for inspection/sampling and cleaning, at all times. The grease trap shall have a minimum of two (2) compartments, with fittings, designed for grease interception.
9. The oil/grease trap shall be located outside the building and at a distance far enough to allow soluble grease/oil to become insoluble.
10. No gravity sewer main conveying raw wastewater shall be less than 8 inches in diameter.

11. All sewers shall be designed and constructed to give mean velocity, when flowing full, of not less than 2.0 feet per second, based on Manning formula using an “n” value of 0.013.
12. Laterals shall be a minimum of 6-inches in diameter with a slope of 1.00%.
13. Service laterals shall be SDR-26 pipe from the sewer main to the building. One lateral shall be installed per building. All laterals shall be inspected by an Aqua representative prior to backfilling.
14. All laterals and tee-wye fittings shall be PVC SDR-26. Saddle connections shall not be allowed for new construction. Lateral connections shall only occur at tee-wyes.
15. A minimum of one clean-out shall be installed for each lateral. Where the length of a lateral exceeds 100 feet, then one clean-out shall be installed for every 100 feet of lateral length. In any event a clean-out shall be located no farther than 4 feet from the building.
16. The lowest internal plumbing elevation to receive gravity sanitary service must be one (1) foot above the top of manhole casting elevation of either the first upstream or downstream manhole on the public sewer to which connection is to be made. Those portions of the building not meeting the stated gravity sanitary service requirement shall be provided and maintained by the property owner with a grinder pump system, or an Aqua approved equal, discharging to the gravity building connection outside of the public right-of-way.
17. Sewer connection permit from Aqua requires a legible diagram, name of property owner, address, telephone numbers of both property owner and contractor, depth and position of lateral between mainline sewer to the building, location of connection point referenced to any permanent object, length and size of pipe to be installed, pipe material, slope of pipe, bedding type, pipe contractor, and method of connection.
18. Contractor shall, when curbs are available, engrave a 3-Inch high by 1/8-Inch deep "S" on the curb directly above each service lateral. Where curbs are not available, contractor shall notch the sidewalk directly above each service lateral.
19. No direct basement connections are permitted.
20. No roof drain connections are permitted.
21. Sanitary Sewers shall not be located in rear yards or other inaccessible areas unless approved by Aqua.
22. All sanitary sewer facilities and laterals shall be separated from existing or proposed waterbodies by a minimum twenty (20) feet horizontally as measured from the outside edge of the sanitary sewer facility to the top of bank. Sanitary sewers, force mains, and laterals crossing existing or proposed lakes, ponds, and/or retention or detention areas (either wet or dry) are prohibited.
23. Castings shall be set at two tenths (0.2) feet above finish grade to insure drainage away from manhole. Castings which are surrounded by asphalt, stone drives or concrete shall be constructed within a tolerance of ± 0.1 feet of the designed elevation. All other castings shall be constructed within a tolerance of ± 0.2 feet of the designed elevation. Elevations will be checked with the as-built drawings. Under no circumstance shall a manhole casting be buried.
24. There shall be a minimum of 0.1 feet of fall between the upstream invert(s) and the downstream invert in a manhole structure for pipes of the same diameter. For change in direction 45 degrees to 75 degrees, a minimum 0.20 feet drop shall be maintained. For change in direction 75 degrees to 90 degrees, a minimum 0.30 feet drop shall be maintained. Changes in direction over 90 degrees are not permitted. For pipes of differing diameters, the crown of the upstream pipe shall match the crown of the downstream pipe. An outside drop manhole is required for upstream inverts which are two feet higher than the downstream invert.

PART 1 - GENERAL

1.1 DEFINITIONS

Bedding: Fill placed under, beside, and directly over pipe, prior to subsequent backfill operations.

Contractor: Company or individual authorized by the Utility to perform work as called for by issuance of a sewer construction permit.

Developer: Any public agency, private company, or individual who proposes the development of property which requires construction of sanitary sewers or laterals.

Embedment: Earth or other special material used to replace material removed from trenches during construction from the sewer subgrade.

Main Sewer: Refers to any existing or proposed sewer dedicated to public use within the public right-of-way or easement.

Lateral: Refers to any existing or proposed pipe which connects from the building plumbing to the main sewer.

Grinder Pump: Refers to a pump used to grind wastewater up and pump it to the nearest gravity sewer.

1.2 ABBREVIATIONS

DI: Ductile iron pipe

IDEM: Indiana Department of Environmental Management

PVC: Polyvinyl chloride plastic

SDR: Standard Dimension Ratio

HDPE: High Density Polyethylene

CCTV: Closed circuit television

IAC: Indiana Administrative Code

1.3 DELIVERY, STORAGE, AND HANDLING

Store plastic piping protected from direct sunlight and support to prevent sagging and bending. Protect stored piping from moisture and dirt by elevating above grade. Protect flanges, fittings, and specialties from moisture and dirt. Handle manholes according to manufacturer's written rigging instructions.

1.4 REFERENCE STANDARDS

The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Most recent standards apply.

A. ASTM International:

1. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
2. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

3. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 4. ASTM D2729 - Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 5. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
 6. ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 7. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
- B. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- C. American Water Works Association (AWWA):
1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 2. AWWA C150 - Thickness Design of Ductile-Iron Pipe.
 3. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.

1.5 COORDINATION

- A. Coordinate connection to sanitary sewer main with the Utility. A Utility representative must be notified a minimum of 48 hours prior to construction startup.

1.6 SANITARY SEWER SERVICE AREA STUDY

- A. The applicant shall prepare a Service Area Study for all proposed sanitary sewer facilities. The intent is to maximize the service area to the greatest extent practical. Aqua Indiana will determine if the projected service area has been maximized. The Service Area Study shall include, at a minimum, the following:
1. Service Area Map
 2. Project boundaries
 3. Projected service area boundaries for collection system
 4. All relevant topographic information with elevation contour lines
 5. Design Flow for projected service area boundary
 6. Existing sanitary sewer facilities with invert and top of casting elevations. As-built information may be used
 7. Any other information deemed necessary by Aqua Indiana
- B. Sanitary sewer facilities must be designed to serve the anticipated flows from the entire upstream service area. Designer shall contact State Utility Engineer to determine the applicability of over-sizing costs for each Project.

1.7 EASEMENTS

- A. Minimum easement width is 20 feet with the sewer centered in the easement. The easement shall be dedicated to the Utility.

Depth of Sewer	Easement Width (feet)
Up to 15 feet	20
15 – 20 feet	25
20 – 25 feet	30
25 – 35 feet	40
Over 35 feet	50

B. A minimum of twenty (20) feet of horizontal separation (as measured horizontally from the sewer spring line) must be maintained between gravity sewers and the top of bank of all water ways, bodies of water and dry detention areas.

C. When crossing a water way, the sanitary sewer facilities should be designed to cross as close to ninety (90) degrees as possible. The Utility will not permit the crossing of bodies of water including, lakes and retention/detention ponds or dry detention areas.

1.8 CLOSEOUT SUBMITTALS

The following documents are required for Utility project acceptance and closeout:

1. Results of all testing (pdf format)
2. CCTV of all sewer lines to be dedicated (video format)
3. As-builts (2) two 24x36" full size copies – paper (certified)
4. As-builts – pdf format (certified)
5. As-builts – electronic CAD format (in State Plane and on NAVD 88)
6. Recorded Plat – pdf format
7. Construction Plans – pdf format
8. Engineer of Record Certification – pdf format
9. Certificate of Sewer Main Cost (Design Engineer certified) – pdf format
10. 2 Year Maintenance Bond (10%) – paper and pdf format
11. Transfer of Ownership – Sewer Facilities – paper (notarized)

PART 2 - PRODUCTS

2.1 EXCAVATION

A. Description

1. The Contractor shall construct all earth excavations to the widths and depths detailed in the drawings. Excavation shall include all kinds of materials, wet and/or dry, excavated, or which are to be excavated, including rock, shale, hardpan, muck, etc.
2. Excavation includes all excavation, surface removal, clearing, disposal of surplus material, dewatering, boring and jacking, and all other work incidental to the construction of trenches or trenchless means for pipe installation. Excavation also

includes the same activities related to the installation of manholes or other required structures.

3. The Developer and his or her Contractor shall be responsible for assuring the protection of all existing improvements, both public and private. The Utility shall be held harmless from any and all damages to said existing improvements during the construction of the improvements.
4. Compliance with these specifications does not eliminate the need to comply with other applicable City, County, State and Federal ordinances, regulations, and construction requirements. This includes but is not limited to codes and standards issued by IDEM, INDOT, or other governmental agencies.
5. The provisions of this document shall be deemed as additional requirements to minimum standards required by other applicable ordinances and standards. In the case of conflicting requirements, the most restrictive shall apply.

2.2 EMBEDMENT AND BACKFILL

A. Description

1. All trenches or excavations shall be backfilled to the original surface of the ground or such other grades as shown on the drawings. In general, backfilling operations shall be carried along as speedily as possible and as soon as the pipe has been laid and bedding has been placed.

B. Definitions and General Considerations

1. Pipe bedding shall be considered the area used for support directly under the pipe for the full width of the trench. The haunch is the area from the top of the bedding to the springline (horizontal centerline of the pipe) for the full width of the trench. Initial backfill is the area from the springline to twelve (12") inches above the crown (top) of the pipe. Pipe embedment is the total area that includes the bedding, haunch and initial backfill. The final backfill is all of the area above the top of the initial backfill elevation.
2. Special foundation material may be required under the pipe bedding for areas of unstable soil material. In circumstances where unstable soil material is encountered, the area shall be excavated and replaced with suitable crushed stone to form a sound foundation. The pipe bedding can then be placed upon the foundation material.
3. The Contractor shall not place pipe embedment materials by methods that will damage or disturb the pipe or other utilities. Care shall be taken that compaction equipment does not come into contact with the pipe. Prior to performing compaction operation over the pipe, the Contractor must ensure that sufficient backfill is installed over the pipe to prevent damage or excessive deflection.

C. Bedding and Backfill of Trench Excavations for Pipes and Conduits

1. Bedding and Backfill materials for pipe installation and trench backfill shall conform to the types detailed in Part 3 of this specification for the specific pipe type installed.

D. Structural Backfill

1. Backfill materials for backfill of structures other than pipes and conduits shall be according the Standard Details.

2.3 GRAVITY SANITARY SEWER PIPE

A. Description

1. The Contractor shall furnish and lay sewer pipe, and all accessories, to the lines and grades shown on the drawings. Sewer pipe shall be constructed of the pipe materials as specified herein and as shown on the drawings.
2. Related work described elsewhere:
 - a. Excavation
 - b. Embedment and Backfill

B. Quality Assurance

1. Codes and Standards
 - a. Each length of pipe shall be marked per the requirements of the respective ASTM Standard.
 - b. All codes and standards shall be set forth in the latest ASTM Standard.
2. Upon request by the Utility, the Contractor shall furnish copies of all material tests required by the applicable ASTM Standard.
3. No public gravity sewer will be less than eight (8) inches in diameter.
4. The Utility will not accept gravity sewers designed or installed below minimum slope as specified in Section 33.41 (Recommended Minimum Slopes) of Recommended Standards for Wastewater Facilities "Ten States Standards" (most recent Edition) and/or 327 IAC Article 3, whichever is more restrictive. It is strongly recommended that gravity sewers be designed at slopes greater than the minimum regulatory requirements.
5. If a drop manhole can be constructed to avoid slopes greater than 5.00%, then Aqua Indiana generally will require the drop manhole to be constructed.
6. Maximum allowed infiltration in new gravity sanitary sewers shall be 100 gallons per 24 hour period per inch-diameter-mile.

C. Polyvinyl Chloride (PVC) Pipe, SDR-35, SDR-26, or SDR-21

1. Material
 - a. Polyvinyl chloride (PVC) for gravity sanitary sewer pipe shall be the integral wall bell and spigot type with elastomeric seal joints and smooth inner walls meeting or exceeding all of the requirements set forth in ASTM D-3034 for pipe diameters 15-inches or less.
 - b. For diameters 15-inches or less, the pipe shall have a minimum cell classification of 12454 or 12364; with all pipe having a minimum tensile strength of 34.50 Mpa as defined in ASTM D-1784.
 - c. PVC sanitary sewer pipe shall have a minimum pipe stiffness of 46 psi for SDR 35 and 115 psi for SDR 26 for each diameter, when measured at 5% vertical ring deflection and tested in accordance with ASTM D-2412.
 - d. For pipe installation where the sewer is closer than 51 feet to a residential water well, the sewer shall be constructed from SDR-21 in accordance with ASTM D-2241, with a minimum cell class of 12454.
 - e. Ultimate Depth (from invert to grade) guidance:

Depth of Sewer	Pipe Type
Up to 15 feet	PVC: ASTM D3034 (SDR 35). ASTM F679 (T-1, SDR 35, PS 46)
Up to 25 feet	PVC: ASTM D3034 (SDR 26), ASTM D2241 (SDR 21, PS 225 or greater), AWWA C-900 (DR 18, PS 364 or greater), or AWWA C-905 (DR 25 or DR 18, PS 115 or greater)
Up to 30 feet	AWWA C-900 (DR 18, PS 364 or greater) or AWWA C-905 (DR 25 or DR 18, PS 115 or greater)
Over 30 feet	Contact State Utility Engineer

2. Joints

- a. Flexible gasket joints shall be compression type so that when assembled, the gasket inside the bell will be compressed radially on the pipe spigot to form a watertight seal. The assembly of joints shall be in accordance with the pipe manufacturer's recommendations and ASTM D-3212 for pipe conforming to ASTM D-3034 or joints shall meet the requirements of ASTM D-3139 for pipe conforming to ASTM D-2241. The gaskets sealing the joint shall be made of rubber of special composition having a texture to assure a watertight and permanent seal and shall be the product of a manufacturer having at least five (5) years of experience in the manufacture of rubber gaskets for pipe joints. The gasket shall be a continuous ring of flexible joint rubber of a composition and texture which is resistant to common ingredients of sewage, industrial wastes and groundwater and which will endure permanently under the conditions imposed by this service. The gasket shall conform to the requirements of ASTM F-477.
- b. NO SOLVENT CEMENT JOINTS SHALL BE ALLOWED.
- c. All field-cutting of pipe shall be done in a neat manner as per manufacturer's recommendations and the cut end shall be beveled using a file or wheel to produce a smooth bevel of approximately 15° and be a minimum depth of one-third the pipe wall thickness. Field cut pipe will only be allowed to be installed at manholes, at prefabricated tees and wyes, and at the connection of new sanitary sewer to existing sanitary sewer.

3. Fittings

- a. All pipe fittings shall be manufactured in accordance with the latest ASTM D-3034 and ASTM F-679 Standards and shall have a minimum pipe stiffness of 46 psi for SDR 35 and 115 psi for SDR 26 in all directions. The minimum cell classification shall be 12454 or 12364 per the latest ASTM D-1784 Standard. All fittings shall be "heavy wall" and provided gaskets meeting or exceeding the standards for the pipe.
- b. All sewer main lateral connections shall be pre-fabricated wye fittings. All pipe fittings shall be injection molded unless prior authorization is granted by the Utility.

- c. Saddle connections shall not be allowed for new construction. For installation of a new lateral on existing sewers, connection with a saddle may be considered on pipe 10-inches in diameter and larger.

4. Design

- a. The minimum wall thickness for PVC sewer pipe and lateral sewer pipe 15- inches or less in diameter shall conform to SDR-35, SDR-26, or SDR-21 as specified in ASTM D-3034 or ASTM D-2241.

5. Markings

- a. The date of manufacture, shift code, class of pipe, ASTM specification designation (e.g. "PVC-SDR-26"), size of pipe, name or trademark of manufacturer, and identification of plant/location shall be legibly marked on the outside of each pipe section and fitting in accordance with the ASTM D-3034.

6. Certification

- a. The Contractor shall furnish, upon request, certified reports stating that inspection and specified tests have been made and that the results thereof comply with the applicable Standards.

D. Polyvinyl Chloride (PVC) Pipe, C-900/C-905

1. Pipe

- a. PVC gravity sewer main pipe shall conform to ASTM Specification D-2241, Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe (SDR PR). The material used shall conform to ASTM Specification D-1784, Standard Specification of Rigid Polyvinyl Chloride and Chlorinated Polyvinyl Chloride compounds, Class 12454. The minimum pressure class for a stream crossing shall be Class 200.
- b. The pipe fittings shall be pressure rated in accordance with recommendations of the Plastic Pipe Institute.
- c. PVC gravity sewer main shall be in compliance with AWWA C-900 for 4" through 12" and AWWA C-905 for 14" and greater. The minimum dimension ratio shall be DR18 with a pressure rating of 235 psi.
- d. All plastic pipe and couplings shall bear identification markings in accordance with Section 2.5.2 and 2.5.3 of AWWA C-900, which shall include the National Sanitation Foundation (NSF) seal of approval. In addition, the plain end of each pipe length shall have two (2) rings, one inch (1") apart, painted around the pipe at the proper location to allow field checking of the correct setting depth of the pipe in the bell or coupling.

2. Joints

- a. Joints shall be bell end or coupling push-on type.
- b. The push-on joint and joint compounds shall meet the requirements for ASTM Specification D-3139, Joint for the Plastic Pipe, using flexible elastomeric seals. The joint shall be designed so as to provide for the thermal expansion and contraction experienced with a total temperature change of seventy-five (75) degrees F in each joint of pipe. Details of the joint design and assembly shall be in accordance with joint manufacturer's standard practice.
- c. The lubricant shall have no deteriorating effects on the gasket or the pipe. The lubricant containers shall be labeled with manufacturer's name.

- d. The gaskets sealing the joint shall be made of rubber of special composition having a texture to assure a watertight and permanent seal and shall be the product of a manufacturer having at least five (5) years of experience in the manufacture of rubber gaskets for pipe joints. The gasket shall be a continuous ring of flexible joint rubber of a composition and texture which is resistant to common ingredients of sewage, industrial wastes and groundwater and which will endure permanently under the conditions imposed by this service. The gasket shall conform to ASTM F-477. Gaskets shall meet all applicable requirements of ANSI Standard A- 21.11.

3. Fittings

- a. Fittings shall be manufactured in one piece of injection molded PVC compound meeting the requirements of ASTM D1784. Fittings shall be designed to withstand a minimum of 755 psi quick burst pressure @ 73 degrees F in accordance with ASTM D1599.
- b. All sewer main lateral connections shall be pre-fabricated wye fittings to fit C900 pipe. All pipe fittings shall be injection molded unless prior authorization is granted by the Utility.

4. Markings

- a. The date of manufacture, shift code, class of pipe, ASTM specification designation (e.g. "PVC-C900"), size of pipe, name or trademark of manufacturer, and identification of plant/location shall be legibly marked on the outside of each pipe section and fitting in accordance with the ASTM D-3034.

5. Certification

- a. The Contractor shall furnish, upon request, certified reports stating that inspection and specified tests have been made and that the results thereof comply with the applicable standards.

E. Non-Pressure Type Transition Couplings

1. Comply with ASTM C1173, elastomeric, sleeve type, reducing or transition coupling, for joining underground nonpressure piping. Include ends to match same sizes of main line piping and install corrosion-resistant metal tension bands and tightening mechanism on each end.
2. Sleeve Materials:
 - a. For Plastic Pipes: ASTM F477, elastomeric seal.
 - b. For Dissimilar Pipes: PVC or other material compatible with pipe materials being joined.
3. Non-Shear, Flexible Couplings:
 - a. Couplings shall be elastomeric sleeve with stainless steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

F. Laterals

1. Laterals shall be 6-inch PVC SDR 26 laid at a minimum of 1.00% slope from the sewer main to the right of way line (or easement line).
 - a. Each property having a separate property owner shall have its own lateral from the building to the mainline sewer.

2. Except as provided in a written approval issued by the Utility, no person shall connect a lateral to a sanitary or combined sewer when the lateral has any of the following sources of clear water:
 - a. Foundation/footing drains;
 - b. Sump pumps with or without foundation drains connected;
 - c. Roof drains;
 - d. Heat pump discharge;
 - e. Cooling water; or
 - f. Any other sources of clear water, such as, but not limited to, yard and / or driveway drains.
3. Basements
 - a. The Utility does not allow any direct basement connections to a gravity lateral.
 - b. All buildings constructed with a basement (below ground level) shall use a sump pit and sewage ejector pump arrangement to lift the sewage above the outside grade relative to the direction and location of the sanitary sewer main (overhead sewer). All piping shall be arranged as to preclude the pump from pumping sewage to an upper level when the pump is pumping against a head (blocked sewer main or lateral).
 - c. A check valve suitable for the pipe material being used shall be installed horizontally in the downstream piping of the ejector pump prior to discharge into the house gravity lateral. The check valve shall be able to withstand normal pumping pressure and water hammer. The check valve shall be accessible for normal maintenance. A ball-type shut-off valve shall be installed on both downstream and upstream side of the check valve for ease of maintenance.
4. The Utility prefers not to install laterals on sewers with an Ultimate Depth of twenty (20) feet or greater and/or to sewers eighteen (18) inches or larger. Therefore, Design Engineer shall contact State Utility Engineer to discuss alternatives. For example, a parallel shallow sewer, special lateral construction, etc.
5. Generally, the Utility does not allow lateral connections to a sewer beyond those installed during original construction. Laterals must connect to the sanitary sewer only at manufactured fittings (except as otherwise permitted by these Design Specifications). If it is determined by State Utility Engineer that an exception should be granted refer to Section 2.9 LATERAL CONNECTION TO EXISTING SEWER LINE.
6. All laterals must be a minimum of six (6) inches in diameter and sized based on the anticipated flows. For example, a lateral servicing a pool house may need to be larger based on the peak filter backwash flow.
7. Lateral length
 - a. Unless approved by State Utility Engineer in writing, no more than one hundred (100) feet of a lateral shall exist within a public right-of-way or beyond the boundary of the lot or parcel for which the lateral is designed to service.
 - b. Unless approved by State Utility Engineer in writing, no lateral shall be greater than two hundred (200) feet in length.
8. Slope

- a. Slope requirements must conform to the latest edition of the State of Indiana (Uniform Plumbing Code), local codes and to these Design Specifications, whichever is more stringent.
 - b. Laterals must be installed at a minimum of 1.00% and where possible, not exceed 6.00%. State Utility Engineer, depending on site conditions, may waive the slope requirements.
9. No more than one (1) building or residence will be permitted to connect into a lateral unless the prior written approval of State Utility Engineer is obtained. Except for existing homes served by laterals installed with new construction two existing homes may be served by a single lateral.
10. Laterals cannot connect directly into a manhole, except as follows:
- a. Approved by State Utility Engineer in writing.
 - b. On deep lines (greater than twelve (12) feet) or interceptors greater than ten (10) inches in diameter.
 - c. On buildings in which Aqua Indiana may wish to flow monitor or sample flow characteristics.
 - d. On buildings in which additional access to the Lateral would be helpful. For example, schools.
11. Laterals must connect to the main line sewer at an angle (as measured from the direction of flow) that is greater than ninety (90) degrees.
12. Where possible, wyes and laterals should be located to avoid the following situations:
- a. Installation on interceptors greater than ten (10) inches.
 - b. Installation on sewers which are concrete encased/capped.
 - c. Installation below pavement or concrete, including streets, driveways, parking lots, etc.
 - d. Installation below storm sewers or water ways.
 - e. Installation below other utilities.
 - f. Installation below mounding, retaining/landscaping/entrance walls and landscaping.
 - g. Installed with less than ten (10) feet of horizontal separation from utilities, streets, storm sewers, water ways, buildings, etc.
13. When a lateral crosses a parcel other than the property it is intended to service, it must be constructed within a sanitary sewer easement or utility easement. The lateral must maintain a minimum horizontal separation of ten (10) feet measured from the spring line of the pipe to the edge of the easement. Additional separation may be required based upon Ultimate Depth of the lateral and/or soil/groundwater conditions.
14. During construction of the main line sewer, laterals must terminate within a sanitary sewer or utility easement and be sealed with a manufactured cap/plug made specifically for the purposed of sealing/capping the end of the sanitary sewer to ensure 100% water tightness. The termination point must be a minimum of five (5) feet from the building line.
15. All PVC fittings must be ASTM D-3034 SDR-26 heavy wall minimum. Bell to spigot fittings may only be approved by the State Utility Engineer.

16. From the building to the main line sewer, it is recommended that a clean-out be installed after every three (3) fittings of 22.5 degrees or more, but in no case exceeding five (5) fittings between clean-outs.
17. When service is from the rear a clean-out must be installed either on the side or front of the building so that a clean-out is always accessible, not fenced in.
18. Type 1 clean-outs must be installed in grass or landscape areas located within three (3) feet of the building's exterior wall. All other installations must be Type 2 or Type 3.
19. All clean-outs must be the same diameter as the horizontal lateral into which the clean-out is connected being a minimum of six (6) inches.

G. Cleanouts

1. PVC Cleanouts:

- a. PVC body with PVC threaded plug: Cleanout shall be as per ASTM D3034. PVC sewer pipe fitting and riser to cleanout.
- b. Cleanout shall be installed at a minimum of 3 feet from the outside of building wall and every 100 feet of lateral until connection at the mainline sewer.
- c. Cleanout Riser: Sewer pipe fitting on main line sewer and riser shall match main line piping.
- d. Cleanout Shut-Off Valve: A cleanout valve shall be provided, Sewur Valve or approved equal.

2.4 PRESSURE PIPE

A. Description

1. The Contractor shall furnish and lay, as required, sanitary pressure pipe, together with all fittings, thrust blocking or other incidentals as shown on the approved plans or specified and, necessary to complete the work. Sanitary pressure pipe shall be constructed of the pipe materials as specified herein.
2. All sanitary pressure pipes to be furnished under this Contract shall conform to specifications of this section.
3. Pressure pipe may be installed by the horizontal directional drilling (HDD) method.
4. Related work described elsewhere:
 - a. Excavation
 - b. Embedment and Backfill
5. Flow from pressure pipes shall be directed towards the outlet pipe within the discharge manhole. Modifications to the bench may be necessary.
6. No public force main will be less than four (4) inches in diameter, except in a low pressure type grinder pump collection system approved by the Utility.
7. Velocities in force mains of less than two (2) feet per second will not be accepted.
8. Force mains must be designed at a constant positive slope from low points and clean-outs to air/vacuum relief valves.

B. Quality Assurance

1. Codes and Standards

- a. Each length of pipe shall be marked per the requirements of the respective ASTM Standard.
- b. All codes and standards shall be set forth in the latest ASTM Standard.
- c. Upon request by the Engineer, the Contractor shall furnish copies of all material tests required by the applicable ASTM Standard.

C. Ductile Iron Pipe

1. Material

- a. Ductile Iron Pipe shall be centrifugally cast and shall conform to ANSI Specifications A-21 and AWWA C-151, latest revision. Ductile Iron Pipe shall be Pressure Class 350, 300 or 250.

2. Coatings and Linings

- a. Pipe shall be sulfate resisting cement lined in accordance with AWWA C-104. The pipe outside shall be seal coated with an approved bituminous seal coat in accordance with AWWA Specification C-151 (ANSI A21).
- b. The pipe shall also have either of the following interior coatings:
 - 1) polyurethane in accordance with ASTM D16 Type V (1000 microns minimum thickness)
 - 2) epoxy (40 mils minimum thickness)
 - 3) polyethylene (1500 microns minimum thickness)

3. Fittings

- a. Fittings shall be standardized for the type of pipe and joint specified and shall comply with AWWA C-110 (ANSI A-21) or AWWA C-153 (ANSI A-21).

4. Joints

- a. Mechanical joints or slip joints shall be provided
- b. Mechanical joints and accessories shall conform to AWWA Standard C-111, ANSI A-21. The bolts and nuts shall be corrosion resistant high strength alloy steel.
- c. The O-ring gaskets sealing the slip joint shall be made of rubber of special composition having a texture to assure a watertight and permanent seal and shall be the product of a manufacturer having at least five (5) years of experience in the manufacturer of rubber gaskets for pipe joints. The gasket shall be a continuous ring of flexible joint rubber of a composition and texture which is resistant to common ingredients of sewage, industrial wastes and groundwater; and which will endure permanently under the conditions likely to be imposed by this service. The gasket shall conform to the requirements of AWWA C-111 (ANSI A-21.11).
- d. Where indicated on plans, restrained joint pipe shall be provided. Restrained joints shall be designed in accordance with AWWA C-111 and shall permit horizontal and/or vertical deflection after assembly, yet adequately restrain the joint at the full design pressure.

5. Ductile Iron Encasement

- a. Polyethylene encasement shall be required for all ductile iron pipe and shall be installed in accordance with ANSI/AWWA C105/A21.5.

6. Markings

- a. The class designations for the various classes of pipe and fittings, manufacturer's name and the year of manufacture shall be cast onto fittings in raised numerals, and cast or stamped on the outside of each joint of pipe.

7. Locating Tracing Wire

- a. All Ductile Iron pipe for pressure sanitary sewer shall be installed with tracing wire. Tracing wire shall be 10 AWG solid copper High Strength Tracer Wire, CCS reinforced by Copperhead or approved equal.
- b. Locating tracer wire shall be brought to surface no less than every 500 L.F.
- c. Locate wire shall be tested for continuity prior to acceptance.

8. Certification

- a. The Contractor shall furnish, upon request, certified reports stating that inspection and specified tests have been made and that the results thereof comply with the applicable standards.

D. Polyvinyl Chloride Pipe (PVC)

1. Pipe

- a. PVC force main shall conform to ASTM D2241, AWWA C900 or AWWA C905.
- b. PVC force main pipe material shall conform to ASTM Specification D-1784, Standard Specification of Rigid Polyvinyl Chloride and Chlorinated Polyvinyl Chloride compounds, Cell Class 12454 (PVC 1120).
- c. For ASTM D2241, the material shall conform to ASTM D1784, Cell class 12454 and hydrostatic design stress of 2000 psi. The minimum pressure class/SDR rating shall be Class 200/SDR 21.
- d. For AWWA C900, the material shall have a design basis of 4000 psi and the minimum pressure class/DR rating shall be Class 200/DR 14.
- e. For AWWA C905, the material shall have a hydrostatic design basis of 4000 psi and the minimum pressure class/DR rating acceptable shall be Class 200/DR 21.
- f. PVC force main shall be in compliance with AWWA C-900 for 4" through 12" and AWWA C-905 for 14" and greater.
- g. All plastic pipe and couplings shall bear identification markings in accordance with Section 2.5.2 and 2.5.3 of AWWA C-900, which shall include the National Sanitation Foundation (NSF) seal of approval. In addition, the plain end of each pipe length shall have two (2) rings, one inch (1") apart, painted around the pipe at the proper location to allow field checking of the correct setting depth of the pipe in the bell or coupling.

2. Joints

- a. Joints shall be bell end or coupling push-on type with joint restraints as needed. Joint restraints shall be Megalug style mechanical joints for PVC pipe as manufactured by EBAA IRON or approved equal.
- b. The push-on joint and joint compounds shall meet the requirements for ASTM Specification D-3139, Joint for the Plastic Pipe, using flexible elastomeric seals. The joint shall be designed so as to provide for the thermal expansion and contraction experienced with a total temperature change of seventy-five (75) degrees F in each joint of pipe. Details of the joint design and assembly shall be in accordance with joint manufacturer's standard practice.

- c. The lubricant shall have no deteriorating effects on the gasket or the pipe. The lubricant containers shall be labeled with manufacturer's name.
- d. The gaskets sealing the joint shall be made of rubber of special composition having a texture to assure a watertight and permanent seal and shall be the product of a manufacturer having at least five (5) years of experience in the manufacture of rubber gaskets for pipe joints. The gasket shall be a continuous ring of flexible joint rubber of a composition and texture which is resistant to common ingredients of sewage, industrial wastes and groundwater and which will endure permanently under the conditions imposed by this service. The gasket shall conform to ASTM F-477. Gaskets shall meet all applicable requirements of ANSI Standard A- 21.11.

3. Fittings

- a. Fittings shall be manufactured in one piece of injection molded PVC compound meeting the requirements of ASTM D1784. Fittings shall be designed to withstand a minimum of 755 psi quick burst pressure @ 73 degrees F in accordance with ASTM D1599.
- b. For restrained joints, fittings shall be restrained joint ductile iron fittings conforming to AWWA C110 and AWWA C111.

4. Locating Tracing Wire

- a. All PVC pipe for pressure sanitary sewer shall be installed with tracing wire. Tracing wire shall be 10 AWG solid copper High Strength Tracer Wire, CCS reinforced by Copperhead or approved equal.
- b. Locating tracer wire shall be brought to surface no less than every 500 L.F.
- c. Locate wire shall be tested for continuity prior to acceptance.

5. Markings

- a. The date of manufacture, shift code, class of pipe, ASTM specification designation ("PVC-C900"), size of pipe, name or trademark of manufacturer, and identification of plant/location shall be legibly marked on the outside of each pipe section in accordance with the ASTM D-3034.
- b. Where C900/905 is used for sewer force main, it shall be green in color to designate it is sewer. Alternately, a plastic tape "sewer" complying with 327 IAC may be installed.

6. Certification

- a. The Contractor shall furnish, upon request, certified reports stating that inspection and specified tests have been made and that the results thereof comply with the applicable standards.

E. High Density Polyethylene Pipe (HDPE)

1. Resin and Material Requirements

- a. All material shall be manufactured from a PE 4710 resin listed with the Plastic Pipe Institute (PPI) as TR-4. The resin material shall meet the specifications of ASTM D 3350 with a minimum cell classification of 445474C. HDPE pipe and fittings shall contain no recycled compounds except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. HDPE products shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids, or other injurious defects.

2. Pipe

- a. Pipe shall be made of HDPE material with a minimum material designation code of PE4710 and with a minimum Cell Classification as noted in 2.01.A. The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black of not less than 2 percent. The manufacture of the HDPE resin shall certify the cell classification indicated.
- b. Pipe sizes 3" and large shall have a manufacturing standard of ASTM F 714, while pipe smaller than 3" shall be manufactured to the dimensional requirements listed in ASTM D 3035. Dimension Ratio (DR) and Outside Diameter (IPS/DIPS) shall be as specified on plans.
- c. Pipe shall meet AWWA C901 (1/2" to 3") or AWWA C906 (4" to 63"), and shall be listed as meeting NSF-61.
- d. The color coding shall be permanently co-extruded stripes on the pipe outside surface as part of the pipe's manufacturing process. Color coding shall be as follows: Sewer – green

3. Joints

- a. HDPE pipe shall be joined into continuous lengths on the job site above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. Electrofusion shall not be used except as needed to connect adjacent directionally drilled sections which are to be connected in the trench bottom. Mechanical joint adapters are required to mechanically connect the HDPE pipe to the main line. Joint restraint to prevent axial separation shall be incorporated into the design of the sleeve or coupling used to connect HDPE pipe plain ends. Internal pipe wall stiffeners must be used when restraining HDPE. The restrained coupling system shall be Series 4800 manufactured by EBAA Iron, Inc. or an approved equal.

4. Fittings

- a. Butt Fusion Fittings- Fittings shall be made of HDPE material with a minimum material designation code of PE4710 and with a minimum Cell Classification as noted in 2.01.A. Fittings shall have a minimum pressure rating equal to or greater than the pipe to which they are joined unless otherwise specified on the plans or accepted by owner/engineer. All fittings shall meet the requirements of AWWA C901 or C906.
 - 1) Molded fittings shall comply with the requirements of ASTM D 3261.
 - 2) All fabricated elbows, tees, reducing tees and end caps shall be produced and meet the requirements of ASTM F 2206, as manufactured by ISCO Industries, Inc or other approved manufacturer holding an ISO 9001 quality system certificate. Each fitting will be marked per ASTM F 2206 section 10 including the nominal size and fitting EDR, which will meet or exceed the pipe DR identified for the project. Fabricated fittings shall be manufactured using a McElroy Data Logger to record fusion pressure and temperature, and shall be stamped with unique joint number that corresponds to the joint report. A graphic representation of the temperature and pressure data for all fusion joints made producing fittings shall be maintained for a minimum of 5 years as part of the quality control and will be available upon request of owner. Test results to validate ASTM F 2206 section 7.3 and 9 shall be provided to owner or owner's representative upon request.
 - 3) Socket fittings shall meet ASTM D 2683.

- b. Electrofusion Fittings - Fittings shall be made of HDPE material with a minimum material designation code of PE 4710 and with a minimum Cell Classification as noted in 2.01.A. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a minimum pressure rating equal to or greater than the pipe to which they are joined unless otherwise specified on the plans. For potable water systems, all electrofusion fittings shall have AWWA approval.
- c. Bolted Connections- Flanges and MJ Adapters shall be fused onto the pipe and have a minimum pressure rating equal to or greater than the pipe unless otherwise specified on the plans.
 - 1) Metallic back-up rings (Van-Stone style lap joint flanges), shall have a radius on the inside diameter of the bore so as to be compatible with HDPE Flanges. Back up rings shall have bolt pattern that will mate with AWWA C207 Class D (generically known as 150 pound patterns).
 - 2) Where shown on the drawings, 4" and larger transitions to mechanical joint fittings and valves shall be accomplished using a MJ Adapter with kit. The D.I./HDPE mechanical joint adaptor shall consist of an HDPE mechanical joint transition fitting, rubber gasket, a mechanical joint backup drive ring, and Corten mechanical joint tee bolts.
- d. Mechanical Fittings: The use of mechanical coupling and saddles shall be approved by the owner or engineer prior to installation. Mechanical Fittings shall be designed for use and compatible with HDPE pipe, including SS stiffeners when required by manufacturer. Mechanical fittings shall have a pressure rating equal to or greater than the pipes.

5. Markings

- a. During the extrusion production, the HDPE pipe shall be continuously marked per ASTM and AWWA with durable printing with, at a minimum, the following: nominal pipe size, dimension ratio, pressure rating, trade name, material classification, certification bases, and date.

6. Locating Tracing Wire

- a. All HDPE pipe for pressure sanitary sewer shall be installed with tracing wire. Tracing wire shall be 10 AWG solid copper High Strength Tracer Wire, CCS reinforced by Copperhead or approved equal.
- b. Locating tracer wire shall be brought to surface no less than every 500 L.F.
- c. Locate wire shall be tested for continuity prior to acceptance.

7. Certification

- a. The Contractor shall furnish, upon request, certified reports stating that inspection and specified tests have been made and that the results thereof comply with the applicable standards.

F. Pressure Type Pipe Couplings:

- 1. Tubular-Sleeve Couplings:
- 2. Couplings shall meet AWWA C219, with center sleeve, gaskets, end rings, and bolt fasteners.
- 3. Metal, bolted, sleeve-type, reducing or transition couplings for joining underground pressure piping:

4. Couplings shall meet a 200-psi minimum pressure rating and ends of same sizes of the main line piping.
5. Center-Sleeve Material:
6. Sleeve shall be Stainless steel.
7. Gasket material: Gaskets shall be natural or synthetic rubber resistant to sewage.
8. Metal component finish: Finish shall be a corrosion-resistant material or coating.

2.5 RESILIENT WEDGE GATE VALVES

- A. Valves shall conform to the latest revision of AWWA Standard C515 covering resilient seated gate valves for water supply service.
- B. The valves shall have a ductile iron body, bonnet, and O-ring plate. The wedge shall be totally encapsulated with rubber.
- C. The sealing rubber shall be permanently bonded to the wedge per ASTM D-429.
- D. Valves shall be supplied with O-ring seals at all pressure retaining joints. No flat gaskets shall be allowed.
- E. The valves shall be non-rising stem opening by turning left and provided with 2" square operating nut or a handwheel with the word "Open" and an arrow to indicate the direction to open.
- F. Stems shall be cast copper alloy with integral collars in full compliance with AWWA. All stems shall operate with copper alloy stem nuts independent of wedge and of stem (in NRS valves).
- G. All stems shall have two O-rings located above the thrust collar and one O-ring below. Stem O-rings shall be replaceable with valve fully opened and subjected to full pressure.
- H. The stems on 4"-20" shall have a low torque thrust bearing located above and below the stem collar to reduce friction during operation.
- I. Waterway shall be smooth, unobstructed and free of all pockets, cavities and depressions in the seat area. Valves 4" and larger shall accept a full size tapping cutter.
- J. The body, bonnet and O-ring plate shall be fusion-bonded epoxy coated, both interior and exterior on body and bonnet. Epoxy shall be applied in accordance with AWWA C550 and be NSF 61 Certified.
- K. Each gate valve shall be installed in a vertical position with a roadway type valve box. Gate valves set with valve boxes shall be provided with a 2-inch square operating nut and shall be opened by turning to the left (counter-clockwise). There shall be a maximum 48" depth of valve operating nut. Contractor must use extension stems, if necessary, to raise operator nut within 48" of final grade.
- L. All buried gate valves shall have mechanical joint ends.
- M. Prior to shipment from the factory, each valve shall be tested by hydrostatic pressure equal to the requirements of AWWA C515 (and UL/FM where applicable).
- N. Valves shall be as manufactured by Mueller, M&H, Clow, American Valve & Hydrant, Kennedy, or approved equal.

2.6 AIR RELEASE VALVES

- A. Valves shall be installed at the high points of the force main or at locations selected by the Engineer. This will permit discharging the surge of air from an empty line when filling and relieve the vacuum when draining the system. Valve shall also release an accumulation of air when the system is under pressure. This shall be accomplished in a single valve body.
- B. An isolation valve shall be furnished and installed between the air release valve and main connection to isolate the air release valve from the system. Valve shall be a full opening stainless steel or bronze ball style valve provided with threaded connections and be installed using stainless steel pipe.
- C. Air release valves shall be combination air release valves (unless otherwise specified by State Engineer) as manufactured by A.R.I. or Owner approved equal. The valve shall allow air to escape out of the large orifice when air is present and close when liquid enters the valve. When the valve is closed and pressurized, the small air release orifice will open to allow small pockets of air to escape automatically and independently of the large orifice. The large orifice shall also allow air to enter to break vacuum. The body inlet shall be baffled to protect the float from direct forces of rushing air and water to prevent premature valve shut-off.
- D. Materials shall conform to the following:
 - 1. Body and Cover: Ductile iron (ASTM A536 GR 65-45-12)
 - 2. Float: Stainless steel (ASTM A240)
 - 3. Needle & seat: Buna-N
 - 4. Plug: Stainless steel (ASTM A276)
 - 5. Leverage frame: Delrin/Cast Iron (ASTM D4184/ASTM A126 GR. B)
 - 6. The valves shall be rated for 150 psi working pressure, and conform to AWWA C512.

2.7 CASING AND JACKING PIPE

A. Description

- 1. All casing and jacking pipe and horizontal bores shall be approved by the Utility.

B. Steel Casing Pipe

- 1. Steel casing pipe shall be constructed in accordance with ASTM A53 with 35,000 psi minimum yield strength, and have the following minimum wall thicknesses:

≤ 24” Steel Casing shall have 0.250” minimum wall thickness
30” Steel Casing shall have 0.375” minimum wall thickness
36” Steel Casing shall have 0.375” minimum wall thickness
42” Steel Casing shall have 0.375” minimum wall thickness

- 2. All encasement pipe joints shall be welded.
- 3. The casing pipe diameter equals the carrier pipe’s largest outside diameter plus 4-inches minimum.
- 4. Carrier Pipe: per Section 2.3 or 2.4 of these Specifications.

C. Casing Spacers

1. Manufactured casing spacers or wood blocking spacers are required on the bottom and top to prevent pipe from “floating” during grout filling procedure.
2. Casing spacers should be at 6-foot maximum, center-to-center, per detail.

2.8 MANHOLES

A. Description

1. Standard manholes shall be constructed complete, ready for use, including excavation, backfill, concrete work, cast iron frames and covers, and pertinent work as shown on the drawings. All manholes shall be made watertight, and the Contractor shall furnish all materials and perform all work necessary for watertight construction.
2. All proposed castings set in paved areas shall be flush with the final pavement elevations. All proposed castings to be set in non-paved areas shall stand approximately three (3) inches above flush with the final ground.
3. Maximum manhole spacing shall be four hundred (400) feet, unless approval is given by the Utility State Engineer.
4. Design Engineer shall verify that the lowest elevation to have gravity sanitary sewer service within each home or building is more than one (1) foot above the lowest top of casting elevation of either the first upstream or downstream manhole on the gravity sewer to which the connection is to be made. This design consideration must be incorporated into finished floor elevations (FFE) and a minimum FFE label for the lots where the pad elevation does not meet this requirement.
5. Manhole elevations must be set eighteen (18) inches above the current published Indiana Department of Natural Resources 100-year base flood elevation of nearby waterways (including, but not limited to, lakes, ponds, streams, and emergency spillways or storm water routing). If this requirement cannot be met, then water tight bolted and gasketed castings must be installed.
6. Manholes shall be installed at a 6-foot minimum depth (7-foot preferred), as measured from the top of casting to the invert.
7. All lift holes in precast sections shall be wetted and completely filled with non-shrink grout, smoothed.
8. Manholes exterior shall be coated with bituminous waterproofing material to ensure water tightness.

B. Reinforced Concrete Manholes and Accessories

1. Manholes shall be constructed in accordance with the ASTM C478, Standard Specifications for Precast Reinforced Concrete Manhole Sections. Manholes shall be a minimum diameter of 48 inches with a minimum access diameter of 24 inches. The minimum wall thickness shall be five (5) inches for manholes four (4) feet in diameter.
2. The precast tops shall be of the eccentric cone type. Precast flat covers shall be not less than eight (8) inches thick and reinforced with two layers of steel with a minimum area of 0.39 square inches per linear foot in both directions in each layer. Precast flat bottoms of manholes shall also be reinforced the same as specified herein for precast flat top. Hoisting lugs or hooks shall be cast in place for handling and setting of the rings. No through holes shall be permitted. Openings of proper sizes and suitable design shall be cast in place for receiving the sewer and/or drop pipes and connections.

Adjusting riser rings shall be provided, with no more than 12-inches of riser rings allowed.

3. All manhole joints shall be tongue and groove and they shall be sealed with 1-1/4" butyl mastic joint sealant meeting ASTM C-990. Cracked or damaged barrel joints shall not be allowed. All joints shall also have an exterior joint wrap similar to the Infi-Shield Gator Wrap as manufactured by Sealing Systems Inc. or approved equal. The joint wrap shall be a minimum of six (6") in width.
4. Manhole steps shall be installed in all sanitary sewer manholes. Manhole steps shall be polypropylene. Manhole steps shall be installed in a vertical row on 16-inch centers.
5. Manhole bases shall be of cast-in-place monolithic concrete or precast concrete. Where sewer lines pass through or enter manholes, the invert channels shall be smooth and semi-circular in cross section with the wall extending to full depth elevation of the pipe. The invert channels shall be formed directly in the concrete of the manhole base. Changes of direction of flow within the manholes shall be made with a smooth curve with as long as a radius as possible. The walls of the channels may be flared out to allow testing equipment to be inserted and removed. The floor of the manhole outside the channels shall be smooth and slope toward the channel not less than one (1) inch per foot.
6. For cast in place bases, no mortar or concrete shall be placed in water, and no water shall be allowed to flow over or against the concrete before it has had adequate time to set in order to prevent damage to the structure.
7. The standard manhole is forty-eight (48") in diameter. Larger diameter manholes may be required in instances with large pipe diameters or with certain internal drops, if approved. Manhole barrel sections shall be in one, two, three, or four foot sections. The cone section shall be of the eccentric cone type, two or three feet in length.
8. Adjusting Rings. Where one (1) solid riser or barrel section cannot be used, final adjustments in elevation of the frame and cover shall only be accomplished by the use of precast concrete adjusting rings conforming to ASTM C 478. Rings shall be of a nominal thicknesses of four (4"), or six (6") inches. Not more than two (2) rings and not more than twelve (12) inches total of adjusting rings shall be allowed for adjustment of the manhole frame and cover to required elevation. Grade ring joints shall have a 1 1/4" thick preformed butyl rubber flexible sealant conforming to ASTM C990.
9. All precast concrete for manholes that will be receiving a force main or are within five hundred (500') feet upstream or downstream of the receiving manhole shall have the interior of the manhole lined with Spectrashield, cementitious liners with calcium aluminate mortars such as StrongSeal, Sauereisen, Madewell, Conco Sprayroq or approved equal. Apply coating per manufacturer's recommendation.
 - a. A bolted and gasketed casting must be installed on each manhole within two hundred (200) feet of a force main discharge.
10. Minimum manhole diameters
 - a. The following are minimum manhole diameters for sanitary sewers entering/exiting a manhole at the following range of angles:

Pipe Size	Pipes Entering / leaving at 0° - 45° Bend	Pipes Entering / leaving at 45° - 90° Bend
8'' - 21''	48''	48''
24''	48''	60''
27'' - 30''	60''	60''
33'' - 36''	60'' *	72''

* Note 72" if the "A-lok" connector is used.

b. The minimum manhole diameter to accommodate an inside drop is 60''.

C. Manhole Base Channels:

1. Manhole channels shall be main line pipe material. Lay main pipe through manhole and cut top of pipe out to be three-fourths of pipe diameter. For all manholes with equal diameter influent and effluent pipes, a minimum 0.10 foot drop between the inverts and effluent pipes shall be maintained. For changes in direction 45 to 90 degrees, a minimum 0.20 foot drop shall be maintained.

D. Sewer Pipe to Manhole Connections

1. To connect a sanitary sewer to a manhole, a resilient pipe to manhole connector shall be used meeting the requirements of ASTM C-923. Either a flexible boot KOR-N-SEAL 1 or 2, cast-in-place Dura-Seal gasket or "A-lok" gasket or an approved equal shall be used. Connections to an existing manhole shall be a flexible boot seal.
2. If the flexible boot connection is used, it shall be placed in the reinforced concrete manhole base and secured to the pipe by a stainless steel clamp. Flexible connectors shall conform to ASTM C 923.
3. All connections shall provide for a watertight seal between the pipe and manhole. The connector shall be the sole element relied upon to assure a flexible watertight seal of the pipe to the manhole.
4. The invert of the connection shall be grouted with non-shrink grout. The remainder of the resilient connection shall be free of grout to promote flexibility of the connection.
5. The rubber for the connector shall conform to ASTM C 923 and shall be resistant to ozone, weather elements, chemicals, including acids and alkalis, animal and vegetable fats, oils and petroleum products.
6. The stainless steel elements of the connector shall be totally non-magnetic Series 305 stainless steel. The stainless steel clamp shall be capable of sustaining applied torque in excess of eighty (80) inch-pounds.
7. For cored holes, penetrations, and/or other opening through a manhole or other sanitary structure, the Utility recommends a separation of greater than eighteen (18) inches between the outer edges of resilient connectors. If a separation of less than eighteen (18) inches exists, then additional reinforcement will be required in the structure or structure diameter shall be enlarged to provide the required separation.

8. All cored holes, penetrations and/or other opening through a manhole or other sanitary structure must have a minimum separation of eight (8) inches from the outer edge of resilient connectors.
9. All cored holes, penetrations and/or other opening into a manhole or other sanitary structure must have a minimum separation of six (6) inches from any joint, as measured from the nearest joint shoulder, to the penetration.
10. New connections made to any existing structure shall be drilled in the direction of flow. The internal base material shall be removed and re-poured with the channels meeting the requirements of the manhole base section. If the structural integrity of the concrete base section is compromised during the removal of the interior base, the entire base section shall be replaced. The connector boot shall be appropriately sized to fit the opening and shall be KOR-N-SEAL® by NPC, Inc., A-Lok Products, Inc., or approved equal.

E. Bench Walls

1. If an end run manhole has no stubs and will be extended in the future, then no bench wall shall be installed until the extension is constructed.
2. If an end run manhole will not be extended in the future, then the bench wall must extend across the entire width of the manhole with a grouted flow transition at the far wall to the top of the bench wall.

F. Invert Elevation Differences

1. The invert elevation difference shall be 0.10 feet in manholes which the effluent and influent pipes create an angle of one hundred thirty-five (135) degrees to one hundred eighty (180) degrees.
2. The invert elevation difference shall be 0.20 feet in manholes which the effluent and influent pipes create an angle of ninety (90) degrees to one hundred thirty-five (135) degrees.
3. The invert elevation difference for manholes in which the effluent and influent pipes create an angle of less than ninety (90) degrees will be determined on a case by case basis. This situation will only be allowed where no other alternative is available and the invert elevation difference shall be a minimum of 0.30 feet.
4. The invert elevation difference in which a smaller sewer joins a larger one is determined as specified in accordance with Section 33.6 (Changes in Pipe Size) of Recommended Standards for Wastewater Facilities "Ten States Standards".

G. Drop Manholes

1. Where a sanitary sewer or sanitary lateral enters a manhole twenty-four (24) inches or more above the invert of the outgoing sewer, the incoming sewer shall be connected to the manhole by means of a drop connection.
2. Outside drop connections may be either precast or field fabricated. Drop connections on the inside of manholes shall be secured to the interior wall of the manhole and provide access for cleaning, and drop pipe connections on the outside of manholes shall be encased in concrete.

H. Sample Manhole Requirements

1. All warehouse and industrial sites shall install a sampling manhole prior to connection to the Utility sewer.

2. The sampling manhole shall be as specified in standard details drawing.
3. The sampling manhole shall have a three (3) foot straight lateral run on both sides of the manhole.
4. The sampling manhole shall be furnished with a flume for flow measurement.

I. Castings

1. Standard manholes shall have a self-sealing, heavy-duty frame and cover, Neenah R-1772 or approved equal. Material shall be in compliance with ASTM A-48, CL 35. Each lid shall have "Sanitary Sewer" molded into the exterior surface in letters two (2) inches in height recessed, and flush with surface.
2. Where watertight castings are required, the manholes shall have a bolt down Neenah 1772 or 1022ZI casting by East Jordan Iron Works, or approved equal. The frame shall be anchored through the riser rings (if provided) to the cone section with four (4) galvanized rods.
3. No open pick holes shall be allowed.

J. Frame, Chimney and Joint Seal

1. All manholes shall have an external chimney seal and joint seals.
2. The section of the manhole from the eccentric cone to the casting frame shall be wrapped on the exterior with joint wrap meeting the requirements of the Uni-Band sealing system as manufactured by Sealing Systems, Inc. or approved equal.
3. All manhole joints shall be wrapped on the exterior with joint wrap meeting the requirements of the Infi-Shield Gator Wrap as manufactured by Sealing Systems Inc. or approved equal. The joint wrap shall be a minimum of six (6") in width.

2.9 LATERAL CONNECTION TO EXISTING SEWER LINE

- A. All sewer lateral pipes and fittings shall not be less than six inches in diameter.
- B. Connection of a new sewer lateral to an existing sewer main shall be made air and watertight in an acceptable manner.
- C. The standard connection shall utilize standard pipe fitting (or manufacturer's recommended adapter) designed to join the type of pipes involved.
- D. Connection of new laterals to existing sewer mains when a standard fitting is not used shall utilize a Romac Industries Style "CB" Sewer Saddle, Ford Sewer Saddle Style FSS Sewer Saddle or approved equal.
- E. CCTV of all new sewer connections shall be performed and submitted to Aqua (video format).

2.10 APPURTENANCES

A. Oil and Grease Interceptor and Grease Removal Pit

1. Pit shall be constructed of reinforced precast concrete or cast-in-place concrete of the shape and configuration indicated on the plans. Precast vaults shall be constructed in accordance with ASTM C857 and be rated for AASHTO HS20-44 loading. The concrete shall have a minimum compressive strength of 5000 psi at 28 days, and reinforcement shall comply with ASTM A615, Grade 60. Access to the pit shall be through 24 inches diameter manhole frame and cover or through hinged aluminum access manways.

2. Baffles shall be constructed of 1/4 inch mild carbon steel with 1/4 inch thermoplastic coating.
3. The pit shall hold a volume of no less than 1000 gallons.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Remove large stones or other hard materials that could damage pipe or impede consistent backfilling or compaction.
- B. Protect and support existing sewer lines, utilities, and appurtenances.

3.2 EXCAVATION

A. Clearing

1. Prior to excavation, areas within the project limits shall be first cleared of obstructions, debris, and existing facilities with the exception of facilities that must temporarily or permanently remain. The Contractor shall remove and keep separate the topsoil, and shall carefully replace it after the backfilling is completed.

B. Protection of Existing Improvements Required to Remain in Place

1. Before any excavation is started, adequate protection shall be provided for all lawns, trees, shrubs, landscape work, fences, sidewalks, hydrants, utility poles, street, alley and driveway paving, curbs, storm sewers, ditches, headwalls, catch basins, surface inlets and all other improvements that are designated to remain in place. Such protection shall be provided as long as necessary to prevent damage from the Contractor's operations.
2. The Contractor shall exercise every precaution to prevent damage to property within and outside the immediate vicinity of the work. The Contractor shall restore the ground surfaces, replace or repair driveways, buildings, fences, retaining walls, culverts, drains, paving, sidewalks, etc., which are removed or damaged during construction and which are designated on the plans to remain in place.

C. Pavement Removal

1. All pavement cutting and removal shall be performed in accordance with the requirements of the regulatory agency responsible for the maintenance of the roadway.

D. Maintenance of Roadway Access

1. All maintenance of traffic shall be in accordance with the requirements of the regulatory agency or authority in charge of maintaining the subject roadway.
2. The Contractor shall not close or obstruct any portion of a public street without first notifying in writing the appropriate regulatory roadway authority. The Contractor should be aware that there is sufficient time allowed for the authority to review and act on the closure request.
3. Unless closure is approved, streets, roads, private ways and walks shall be maintained passable by the developer's contractor at all times, and the contractor shall be responsible for the adequacy and safety of provisions made.
4. To protect persons from injury and to avoid property damage, adequate barricades, construction signs, warning lights, and guards as required shall be placed and

maintained during the progress of the construction work and until it is safe to use the construction area for its normal purposes.

E. Utility Protection

1. Prior to proceeding with excavation, the Contractor shall initiate the location of all utilities in the area to aid in locating their underground services. Upon location of utilities, the Contractor shall use care in excavating near existing utilities in order to protect them from damage.

F. Deviations from Line and Grade due to Unforeseen Underground Issues

1. Wherever obstructions are encountered during the progress of the work and interfere to such an extent that an alteration in the plan is required, the Engineer may revise the plans and request a deviation from the line and grade or arrange with the owners of the structures for the removal, relocation or reconstruction of the obstructions. Where sewer, gas, water, telephone, electrical or other existing utilities are an impediment to the vertical or horizontal alignment of the proposed pipe line, the Contractor must arrange with the conflicting utility to relocate or have the Engineer revise the drawings to avoid the conflict. All changes in the lines or grades on the plans must be approved by the Utility prior to continuing construction.

G. Construction in Easements

1. In easements across private property, the Contractor shall confine all operations to the easement area. In general, the easement area is intended to provide reasonable access and working area for efficient operation by the Contractor. Where adequate easement space for efficient operation is not provided, the Contractor shall adjust construction methods to complete the work within the easement or work with the Utility to grant or acquire additional easement.

H. Maintenance of Existing Drainage Flow

1. The Contractor shall make provisions for handling and maintaining all flows in existing creeks, ditches, sewers and trenches by pipes, flumes or other approved methods at all times when his operations would, in any way, interfere with the natural functioning of said creeks, ditches, sewers and drains.
2. No storm water shall be permitted in the sanitary sewer.

I. Trench Dimensions

1. The width of trenches in earth for sewer pipe, laterals, and other structures shall provide a trench width of approximately 1.25 times the outside diameter of the pipe plus twelve (12") inches.
2. Sidewalls of pipe trenches shall be vertical from the bottom of the trench to a point not less than twelve (12") inches above the top of the pipe. Above that point, sidewalls may be battered to such slopes as directed on the plans to maintain a safe working environment.
3. Trench sheeting and bracing or a trench shield or box shall be used as required by the rules and regulations of OSHA. The bottom of the trench shall conform to the details shown on the approved plans.

J. Earth Excavation

1. Earth materials shall be excavated so that the open cuts conform to the lines, grades and dimensions shown on the drawings.

2. After the trench is excavated to grade, the Engineer shall examine the base and determine whether or not it is satisfactory for pipe laying. If the base is not satisfactory, it shall be removed and replaced with crushed stone as ordered by the Engineer. The crushed stone shall be #8 gradation as specified in INDOT Standard Specification, and extend a minimum depth of six inches (6") below the barrel of the pipe. Should the base still not be suitable for adequate support of the pipe (i.e. a boiling or quicksand condition, muck, etc.), the Contractor shall propose alternate methods of suitable construction practices to the Utility for approval. The Utility shall approve alternate base stabilization methods prior to commencing laying of pipe in the trench.
3. Excavated earth materials that are suitable for backfilling may be used for backfill when allowed by the approved plans and specifications. This excavated material may only be used as final backfill in areas not subject to traffic loading or pavement, and as shown on the project drawings and details.
4. The trench and trench bottom should be constructed in accordance with ASTM D 2321 - Section 7. Embedment materials should be Class I, Class II or Class III materials as defined in ASTM D 2321 - Section 6. The use of Class IV and/or Class V materials for embedment is not recommended and should be allowed only with the approval of the engineer. Bedding of the pipe should be performed in accordance with ASTM D 2321 - Section 8. Compaction should be as specified in ASTM D 2321. Deviations from the specified compaction shall be approved by the State Utility Engineer.

K. Boring and Jacking

1. If called for on the drawings, boring and jacking of pipe may be required. The same standards for line and grade in open cut installations apply to boring or jacking of pipe.

L. Removal of Water

1. The Contractor shall at all times during construction provide and maintain ample means and devices with which to remove and properly dispose of all water entering the excavations or other parts of the work and shall keep the excavations dry until the structures to be built therein are completed or connections to existing structures are completed.
2. The Contractor shall be responsible to provide all equipment and labor to maintain bypass pumping during connections to existing structures. The Contractor shall maintain adequate pumping capacity at all times to prevent any spills, overflows, or discharges from the existing sanitary system.

3.3 EMBEDMENT AND BACKFILL

A. Pipe Embedment and Compaction

1. For the purpose of this specification, pipe shall include those made of PVC, HDPE, Ductile Iron, and other materials approved by the Utility.
2. All non-rigid pipe shall be bedded, haunched, and initially backfilled with #8 crushed stone or #8 fractured face aggregate. The pipe bedding shall be placed on a prepared flat trench bottom. The pipe bedding shall extend a minimum of six (6") inches or one half (1/2) the outside pipe diameter to a maximum of eight (8") below the pipe. After the pipe has been placed to grade and line, there remains a 4-inch minimum depth of material below the pipe barrel and a minimum of 3-inches below the bell.

3. This same granular material shall be used to haunch (area from the top of the bedding to the springline of the pipe) and for initial backfill (area from the haunch to twelve (12") inches above the pipe) on both sides of the pipe for the full trench width.
4. All materials shall be placed in the trench in no more than six (6") inch layers. Each layer shall be leveled and evenly distributed on both sides of the pipe so as not to disturb, displace or damage the pipe and shall be thoroughly compacted. Compaction of the crushed stone shall be accomplished by hand tamping or walking in the material. Material for haunching can be compacted by manual compaction methods or by shovel slicing.
5. Final backfill is considered to be all material above an elevation that is twelve (12") inches above the top of the pipe to the bottom of the surface restoration (top soil, pavements, sidewalks, etc.) for the full width of the trench. All sanitary sewer pipe shall be backfilled the same day that it is installed. Prior to using heavy compaction or construction equipment directly over the pipe, ensure that sufficient backfill material is installed over the pipe to prevent damage or excessive deflection. Granular backfill shall be required for all pipe under walks or pavement.
6. Compaction of final backfill in areas subject to traffic influence or pavement, which are defined as being area subject to routine vehicle usage such as roadways, alleys, driveways, sidewalks, etc. shall be performed according to the latest revision of the roadway regulatory authority standards (State, County or City). The area of traffic influence is normally considered the area within five (5') feet of the edge of pavement, including shoulders as measured from the outermost edge of the pipe trench closest to the edge of the traffic area. It also includes areas within a 1:1 slope from the edge of the traffic area, based upon depth and distance, taken from the outer edge of the pipe closest to the traffic. Placement and compaction of the final backfill shall be in accordance with the standards of the regulatory agency having jurisdiction over the roadway.
7. Pipes installed in areas not subject to traffic influence may be backfilled with suitable excavated trench soil materials. Excavated trench soil materials shall be placed in uniform layers, compacted as specified, and mounded to accommodate settlement during the project development. Excavated trench material for usage as final backfill shall be free from rocks (two inches in diameter or greater), concrete, roots, stumps, large amounts of sod or organic matter, rubbish, frozen materials and other similar materials that may cause excessive settlement. To allow for settlement, the surface of the trench shall generally be left in a slightly rounded condition.
8. Haunching and initial backfill should be as specified in ASTM D 2321 - Section 9 using Class I, Class II or Class III materials. Materials used and compaction shall be as specified by the engineer. In cases where a compaction of 85 percent Standard Proctor Density is not attainable, the designer may wish to increase the SDR of the pipe to provide adequate stiffness. ASTM D 2321 - Section 11.2, Minimum Cover for Load Application, Section 11.3, Use of Compaction Equipment and Section 11.4, Removal of Trench Protection, should apply unless directed otherwise by the State Utility Engineer.

B. Structures Embedment and Compaction

1. For purposes of this specification, structures shall include but not be limited to vaults and manholes, Items specifically excluded from this definition of "structures" are pipe, conduits and their appurtenances except those listed herein.

2. Structure backfilling and compaction shall comply with the requirements as specified for the adjacent sanitary sewer.
3. All excavations shall be backfilled to the original surface of the ground or such other grade as shown on the plans. The backfilling shall be performed as soon as possible after concrete, mortar and pipe joints have sufficient strength to resist the imposed load without damage. All appurtenances and attachments to structure walls shall be made and any wall coatings shall be in place and cured prior to backfilling at that elevation.
4. Prior to backfilling, all formwork and construction debris will be removed. Any frozen or wet subsoil will be thawed or dried and compacted or removed prior to receiving backfill. During cold seasons, grades receiving backfill will be protected from frost during the work progress.
5. Rainfall and/or groundwater trapped in the excavation during backfill operations shall be pumped out by the Contractor. Excessively wet soil or soil which has eroded into the excavation shall be removed or excavated and re-compacted prior to placing additional backfill material.
6. Openings in structures to receive pipe shall be temporarily plugged or bulkheaded during backfill operations. Backfill shall proceed to an elevation level with the invert of the pipe. The pipe shall then be bedded and backfilled in accordance with the applicable drawing details and specifications.

C. Temporary Surfaces Subject to Traffic

1. The Contractor shall open streets to traffic immediately after completing the backfill operation. The Contractor shall accomplish this by installing the compacted aggregate base immediately after granular backfill. When temporary asphalt pavement is required this shall also be installed immediately. The Contractor shall be responsible for the maintenance of the temporary surface to promote safety of the travelling public.

D. Maintaining Trench Surfaces

1. All surface settlement of the backfill along trenches located beneath streets, roads, alleys, driveways and parking lots which are subject to traffic shall be kept filled level with or slightly above the original paved surface at all times with compacted aggregate base material until the permanent pavement is satisfactorily restored. When temporary asphalt pavement is used, depressions and "pot holes" shall be promptly filled with the temporary asphalt material. Attention shall be given by the Contractor to the timely and proper maintenance, leveling and grading of the surface of all backfilled trenches, especially those subject to traffic and especially following rains. The surface of streets, roads and alleys shall be maintained smooth and free of ruts and water trapping depressions by periodic blading, scarifying; and/or filling settled areas, ruts, pockets, or holes with compacted aggregate base material or temporary asphalt where used.
2. In existing residential areas where stone aggregate has been temporarily used to restore the roadway surface, dust prevention may be required to reduce the effect of dust upon local residents.
3. In areas outside of the influence of traffic, unless otherwise specified, the backfill shall be neatly rounded over the trench to a sufficient height to allow for settlement to grade after consolidation. Prior to the acceptance of the work, any surface settlement below original ground surface shall be refilled and restored.

3.4 GRAVITY SANITARY SEWER PIPE INSTALLATION

A. Description

1. This section on the laying of sewers addresses non-rigid pipe. Polyvinyl Chloride (PVC), HDPE, either AWWA C900/C905 or SDR 35, 26 or 21, pipe shall be considered non-rigid or flexible conduits.
2. All pipes shall be handled, stored and installed according to the manufacturer's recommendations.
3. The minimum cover for sanitary sewer shall be five (5) feet. The maximum allowable depth shall be per manufacturer's recommendations and shall be based upon the bedding and backfill used for the installation.
4. The least amount of lateral cover is generally where the lateral crosses below the gutter of the street on the far side of the road. The State Utility Engineer calculates lateral cover by assuming:
 - a. The lateral invert elevation is the top of pipe elevation of the main line to which the lateral connects.
 - b. The lateral is installed at 1.00%.
5. Sanitary sewers shall be constructed with a ten (10) foot minimum separation from an existing or proposed water main and/or storm sewer, measured horizontally from the outside edge of the sanitary sewer to the outside edge of the water main or storm sewer. A vertical separation of a minimum of eighteen (18") inches, measured vertically from the outside edge of the sanitary sewer to the outside edge of the water main or storm sewer, must also be maintained. When a sanitary sewer main crosses a water main or storm sewer, it shall cross at as nearly to ninety (90) degrees as possible but not less than forty-five (45) degrees, measured from the centerlines of the sanitary sewer and water main or storm sewer. No sanitary manhole shall be located within eight (8') feet of a water main or storm sewer, measured from the outside edge of the sanitary sewer manhole to the closest outside edge of the water main or storm sewer.
6. Where required horizontal and/or vertical separation from water or storm sewer lines cannot be met, the sewer material shall be constructed of PVC SDR 21 or PVC AWWA C900/C905 pipe for a distance of ten (10') feet on either side of the crossing point and shall meet the requirements of 327 IAC.

B. Alignment and Grade

1. All pipe shall be constructed beginning from the lowest point and shall begin at either a new structure or connection to an existing structure. Construction shall proceed to the lines and grades shown on the approved drawings. Line and grade between manholes shall be maintained by use of laser.
2. The Utility will not accept gravity sewer designed or installed below minimum slope as specified in 327 IAC Article 3.
3. The minimum slope of end run gravity sewers shall be 1.00%. End run length shall be maximized to reduce the number of manholes. An end run sewer is defined as follows:
 - a. The upstream manhole has no influent flows from sewers, and
 - b. A sewer is not planned to be extended from the upstream manhole in the future.
4. The Contractor shall verify the initial starting elevation from at least two (2) established benchmarks.

C. Trenching

1. General

- a. Excavation and backfilling shall be performed according to the Embedment and Backfilling section, Section 3.3 of these specifications.

- D. Pipe Laying

1. All pipe, fittings and valves shall be lowered carefully into the trench in such a manner as to prevent damage to materials and protective coatings and linings. Under no circumstances shall gravity sewer main materials be dropped or dumped into the trench. The trench shall be dewatered prior to installation of the pipe.

2. Examination of Material

- a. All pipe, fittings and valves and other appurtenances shall be examined carefully for damage and other defects immediately before installation.

3. Pipe Ends

- a. All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped clean and dry and be free from dirt, sand, grit or any foreign materials before the pipe is laid.

4. Pipe Cleanliness

- a. Foreign material shall be prevented from entering the pipe while it is being placed in the trench.

5. Pipe Placement

- a. As each length of pipe is placed in the trench, the joint shall be assembled and the pipe brought to correct line and grade. The pipe shall be secured in place with specified backfill material.

6. Pipe Plugs

- a. At times when pipe-laying is not in progress, the open ends of pipe shall be closed by a watertight plug. The plug shall be fitted with a means for venting. When practical, the plug shall remain in place until the trench is pumped completely dry. Care must be taken to prevent pipe flotation, should the trench fill with water.
 - b. Prior to removal of the plug for extending the line or for any other reason, air and/or water pressure in the line shall be released.

- E. Joint Assembly

1. Joints shall be assembled in accordance with the manufacturer's instructions.

2. Assembly

- a. After placing a length of pipe in the trench, the manufacturer's lubricant shall be properly applied. Spigot end shall then be centered in the bell and the pipe pushed home and brought to correct line and grade. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipe of proper dimensions to insure such uniform space. Precautions shall be taken to prevent dirt from entering the joint space.

3. Pipe Cutting

- a. Cutting pipe for insertion of valves, fittings, or closure pieces shall be done in conformance recommendations of the manufacturer of the cutting equipment.

Cutting shall be done in a safe, workmanlike manner without creating damage to the pipe lining. An oxyacetylene torch shall not be used.

- b. Cut ends and rough edges shall be ground smooth, and for push-on joint connections the cut end shall be beveled by methods recommended by the manufacturer.

3.5 PRESSURE PIPE INSTALLATION

A. Description

1. Pressure sewer mains shall be installed in accordance with AWWA/ASTM D-2774 standards and manufacturer's recommendations. If any conflict between these standards and manufacturer's recommendations, the manufacturer's recommendations shall take precedence.

B. Alignment and Grade

1. The pressure sewer mains shall be laid and maintained to lines and grades established by the drawings, with fittings and valves at the required locations. Valve operating stems shall be oriented in a manner to allow proper operation.
2. Clearance
 - a. When crossing existing pipelines or other structures, alignment and grade may be adjusted as necessary, to provide clearance as required by federal, state, and local regulations and to prevent future damage or contamination of either the pipelines or structures.
3. Depth
 - a. The minimum vertical cover for sanitary force mains shall be four and a half (4.5) feet from grade to the crown of the pipe. The maximum allowable depth shall be per manufacturer's recommendations and shall be based upon the bedding and backfill used for the installation.
4. Slope
 - a. Force mains must be designed at a constant positive slope from low points and clean-outs to air/vacuum relief valves.

C. Trenching

1. General
 - a. Excavation and backfilling shall be performed according to the Embedment and Backfilling section, Section 3.3 of these specifications.

D. Pipe Laying

1. All pipe, fittings and valves shall be lowered carefully into the trench in such a manner as to prevent damage to materials and protective coatings and linings. Under no circumstances shall pressure sewer main materials be dropped or dumped into the trench. The trench shall be dewatered prior to installation of the pipe.
2. Examination of Material
 - a. All pipe, fittings and valves and other appurtenances shall be examined carefully for damage and other defects immediately before installation.
3. Pipe Ends
 - a. All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be

wiped clean and dry and be free from dirt, sand, grit or any foreign materials before the pipe is laid.

4. Pipe Cleanliness

- a. Foreign material shall be prevented from entering the pipe while it is being placed in the trench.

5. Pipe Placement

- a. As each length of pipe is placed in the trench, the joint shall be assembled and the pipe brought to correct line and grade. The pipe shall be secured in place with specified backfill material.

6. Pipe Plugs

- a. At times when pipe-laying is not in progress, the open ends of pipe shall be closed by a watertight plug. The plug shall be fitted with a means for venting. When practical, the plug shall remain in place until the trench is pumped completely dry. Care must be taken to prevent pipe flotation, should the trench fill with water.
- b. Prior to removal of the plug for extending the line or for any other reason, air and/or water pressure in the line shall be released.

E. Joint Assembly

1. Joints shall be assembled in accordance with the manufacturer's instructions.

2. Assembly

- a. After placing a length of pipe in the trench, the manufacturer's lubricant shall be properly applied. Spigot end shall then be centered in the bell and the pipe pushed home and brought to correct line and grade. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipe of proper dimensions to insure such uniform space. Precautions shall be taken to prevent dirt from entering the joint space.

3. Pipe Cutting

- a. Cutting pipe for insertion of valves, fittings, or closure pieces shall be done in conformance recommendations of the manufacturer of the cutting equipment. Cutting shall be done in a safe, workmanlike manner without creating damage to the pipe lining. An oxyacetylene torch shall not be used.
- b. Cut ends and rough edges shall be ground smooth, and for push-on joint connections the cut end shall be beveled by methods recommended by the manufacturer.

F. Installation by Horizontal Directional Drilling (HDD)

1. Equipment

- a. The directional drilling system shall be remotely steerable and permit electronic monitoring of tunnel depth and location. The system shall be able to control the depth and direction of the pipe and must be accurate to +/- 2 inches.
- b. The system shall utilize a fluid-cutting process, using a liquid clay such as bentonite. This clay shall be totally inert and contain no risk to the environment.
- c. The liquid clay shall remain in the bore hole to increase the stability of the bore hole and to provide a lubricant to reduce frictional drag when the pipe is installed.
- d. The spoils shall be recovered by use of a vacuum system mounted on a vehicle for removal of the spoils. Spoils shall not be discharged into sewers or storm drains. The Contractor is responsible for disposal of all spoil material.

2. Drilling Procedure

- a. Contractor shall calibrate the directional drilling head locator at the start of the day and at each new directional drilling operation.
- b. The maximum drill angle shall be fifteen degrees measure perpendicular to grade to the design depth elevation.
- c. A pilot hole shall be drilled on the drill path with no deviations greater than 5% of depth over a length of 100 feet.
- d. Upon successful completion of the pilot hole, CONTRACTOR will ream the drill hole to a minimum of 25% greater than the outside diameter of the installed pipe using the appropriate tools.
- e. Three strands of tracer wire shall be pulled back with the pipe. The wires shall be installed along the pipe, fastened securely to the pipe at five (5) foot intervals, and terminating above ground with the lead taped around each structure.
- f. Test/pressure relief holes (potholes) dug every 25 feet shall be required along the bore route to confirm alignment and grade, and to relieve subsurface pressure.
- g. After the pipe has been installed, allow pipe manufacturer's recommended amount of time, but not less than four (4) hours, for cooling and relaxation due to tensile stressing prior to hydrostatic testing.

G. Thrust Restraint

1. Fittings

- a. All plugs, caps, tees, reducers and bends, unless otherwise specified, shall be provided with suitably restrained joints. Valves are considered dead ends and shall be restrained as such. See Thrust Blocking detail on Aqua Indiana's Lift Station detail sheet.
- b. No fittings of greater than forty-five (45) degrees (1/8 bend) can be used, except within the valve vault.

2. Design

- a. The design pressure is the maximum pressure to which the pipeline will be subjected, with consideration given to the vulnerability of the pipe soil system when the pressure is expected to be applied. In most cases, this will be the test pressure of the pipe, applied shortly after installation, when the pipe-soil system is normally most vulnerable.
- b. For buried pipelines, thrust restraint is achieved by transferring the thrust force to the soil structure outside the pipe. The objective of the design is to distribute the thrust forces to the soil structure in such a manner that joint separation will not occur in unrestrained joints.

3. Restraining mechanisms for push-on or mechanical joints: Tie rods, clamps, or other components of dissimilar metal shall be protected against corrosion by hand application of a suitable coating or by encasement of the entire assembly with 8-mil loose polyethylene film in accordance with ANSI/AWWA C105/A21.5.

- a. Glands shall be manufactured of ductile iron conforming to ASTM A536- 80, Grade 60-42-10. Set screws shall be hardened ductile iron. These devices shall have pressure rating with a safety factor of 281. Glands shall be listed with UL and Factory Manual.

H. Air Relief

1. Air relief valves shall be installed at every intermediate apex point where air may accumulate in the force main.
2. Each air relief valve that exhausts above ground must be equipped with an exhaust pipe extending to a downward facing elbow covered with a corrosion-resistant, twenty-four (24) mesh screened opening at an elevation of eighteen (18") inches above ground.
3. Automatic air relief valves shall not be used in areas within the one hundred (100) year flood elevation or in areas where flooding may occur unless they are equipped with a downward facing exhaust pipe covered with a corrosion-resistant, twenty-four (24) mesh screened opening at an elevation of eighteen (18) inches above the ground surface and above the one hundred (100) year flood elevation.
4. Manually operated air relief valves shall be used in areas within the one hundred (100) year flood plain and where flooding may occur.

I. Force Main Discharge to Manholes

1. It is recommended that the discharge be one hundred eighty (180) degrees from the effluent sewer. If the discharge cannot be one hundred eighty (180) degrees from the effluent sewer, then it must be constructed two (2) inches above the top of the effluent pipe, but not greater than two (2) feet above the invert of the effluent pipe.
2. Channels must be provided in the manhole for all force main discharges.
3. Channels must be the size of the effluent sewer.
4. Channels must be straight (not with a radius) to the greatest extent possible.
5. Channels must be designed with the same elevation difference as specified for Sanitary Sewer Manholes in this section of these Design Specifications.

3.6 HORIZONTAL BORING INSTALLATION

A. Pits or Approach Trenches

1. Excavate approach trenches or pits as site conditions require.
2. Ensure casing entrance faces as near perpendicular to alignment as conditions permit.
3. Establish vertical entrance face at least 1 foot above top of casing.
4. Install dewatering measures and excavation supports.

B. Casing Pipe

1. Boring:
 - a. Push pipe into ground with boring auger, rotating within pipe to remove soil.
 - b. Do not advance cutting head ahead of casing pipe, except for distance necessary to permit cutting teeth to cut clearance for pipe.
 - c. Arrange machine bore and cutting head to be removable from within pipe.
 - d. Arrange face of cutting head to provide barrier to free flow of soft material.
 - e. If unstable soil is encountered during boring, retract cutting head into casing to permit balance between pushing pressure and ratio of pipe advancement to quantity of soil.
 - f. Grout to fill voids if voids develop greater than outside diameter of pipe by approximately 1 inch.

g. If boring is obstructed, relocate, jack, or tunnel as directed by the Utility representative.

2. Jacking:

- a. Construct adequate thrust wall normal to proposed line of thrust.
- b. Impart thrust load to pipe through suitable thrust ring sufficiently rigid to ensure uniform distribution of thrust load on full pipe circumference.

3. Carrier Pipe:

- a. Clean and inspect pipe.
- b. Place carrier pipe per detail. Exercise care to prevent damage to pipe joints when carrier pipe is placed in casing.
- c. Support pipeline within casing so no external loads are transmitted to carrier pipe.
- d. Attach supports to barrel of carrier pipe; do not rest carrier pipe on bells.
- e. The annular space between the casing pipe and the carrier pipe shall be grout filled.

3.7 MANHOLES

A. Installation

1. All manholes shall be installed so that the top of the manhole casting and frame:
 - a. In areas not subject to traffic, the lid shall be set at three (3") inches above the surrounding surface after earth settlement.
 - b. In areas subject to traffic, the lid shall be flush with the final ground elevation.
2. All structures shall be bedded on a minimum of twelve (12") inches of compacted aggregate meeting the gradation of #8 crushed stone per INDOT Standard Specifications. No structure shall be set on soft or yielding soils. If yielding soils are encountered, the area shall be excavated and filled with compacted crushed stone.
3. All lift holes in precast sections shall be wetted and completely filled with non-shrink grout, smoothed and coated with bituminous waterproofing material to ensure water tightness.
4. Install exterior chimney and joint wraps per Manufacturer's instructions.

B. Regrading

1. Raise or lower existing manholes and structures frames and covers, cleanout frames and covers and valve boxes in regraded areas to finish grade. Carefully remove, clean and salvage cast iron frames and covers. Adjust the elevation of the top of the manhole or structure as detailed on the drawings. Adjust the elevation of the cleanout pipe riser, and reinstall the cap or plug. Reset cast iron frame and cover, grouting below and around the frame. Install chimney seal around reset frame and cover as specified for new construction.
2. During periods when work is progressing on adjusting manholes or structures cover elevations, the Contractor shall install a temporary cover above the bench of the structure or manhole. The temporary cover shall be installed above the high flow elevation within the structure, and shall prevent debris from entering the wastewater stream.

3.8 APPURTENANCES

A. Oil and Grease Interceptor and Grease Removal Pit Installation

1. Pipe and fittings shall be PVC, piping shall be used inside of trap, between trap and buildings, and between trap and manhole.
2. Manways and access manholes shall be set to finish grade providing adequate access to the unit. Slope pavement around the access-way to prevent stormwater from entering the unit.

B. Cleanout Installation

1. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Install cleanout shut-off valve (Sewur Valve by Kodiak Controls, Inc. or approved equal). Cleanouts shall match detail. Install piping so cleanouts open in direction of flow in sewer pipe.
2. Set cleanout frames and covers in earth in cast-in-place-concrete, 18 by 12 inches 1 inch above surrounding grade.
3. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.
4. The top of the cleanout assembly shall be 2 inches below the bottom of the cover to prevent loads being transferred from the frame and cover to the piping.

C. Building Service Lines

1. Install sanitary sewer service lines to point of connection within 3 feet outside of building(s) where service is required and make connections.

D. Sampling Manhole

1. Install sampling manhole prior to connection to the Utility sewer in a location accessible to the Utility and Aqua Indiana personnel.
2. The sampling manhole shall have a three (3) foot straight lateral run on both sides of the manhole.

PART 4 - TESTING

4.1 FIELD QUALITY CONTROL

- A. All systems shall be inspected and tested. A Utility representative must be present for all testing. Aqua Indiana shall be contacted 48 hours prior to any testing. Prior to final acceptance, provide a video record of all piping for sanitary sewer main extensions to show the lines are free from obstructions, properly sloped and joined.
- B. Gravity Sanitary Sewers
 1. Once constructed, all sanitary sewers and manholes shall be watertight and free from leakage. The Contractor shall be required to repair all visible leaks. The rate of infiltration into the sanitary sewer system between any two adjacent manholes shall not be in excess of 100 gallons per inch of pipe diameter per mile per day.
 2. All gravity sanitary sewers constructed of flexible pipe shall be deflection tested no sooner than thirty (30) days after installation and complete backfill. The diameter of the rigid ball or mandrel used for a deflection test shall be no less than ninety-five percent (95%) of the base inside diameter of the pipe to be tested dependent on what is specified in the corresponding ASTM standard. The test shall not be performed with the aid of a mechanical pulling device.

3. All sewers twenty-four (24) inches and less shall be tested by means of a low-pressure air test to detect damaged piping and/or improper jointing. Testing shall be done per ASTM F-1417 for flexible and semi-rigid pipe. See Table 1 for time requirements. The line shall be accepted if the time shown in Table 1 for the designated pipe size and length elapses before the air pressure drops 1 psig below the stable internal air pressure, at which time the test can be discontinued for the accepted line.
4. All sewers greater than twenty-four (24) inches shall be joint tested using air or water under low pressure. All joints shall be tested. Testing procedures shall be per ASTM C-1103.
5. The Contractor shall supply all equipment necessary to perform the tests required.
6. All tests shall be conducted under the observation of a representative of the Utility. It shall be the Contractor's responsibility to schedule testing.
7. Any leakage found during the infiltration test shall be corrected prior to acceptance. Grouting of the joint or crack to repair the leakage shall not be permitted for flexible pipe. If the defective portion of the sanitary sewer cannot be located, the Contractor shall remove and reconstruct as much of the work as is necessary to obtain a system that passes infiltration requirements.
8. All sewer main extensions shall be televised prior to acceptance of sewer by the District.

C. Pressure Pipe

1. After the pipe has been laid and backfilled, all newly laid pressure pipe or any valved sections of it shall, unless otherwise expressly specified, be subjected to a hydrostatic pressure tests. The duration of each pressure test shall be for a period of not less than two hours and not more than six hours. The basic provisions of AWWA C 600 (DI pipe), C 605 (PVC pipe), shall be followed for all pressure testing.
2. The test pressure shall not exceed pipe and/or thrust resistant design pressures. The test pressure shall not vary by more than plus or minus 5 psi for the duration of the test.
3. All newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure of at least 1.5 times the maximum working pressure at the lowest elevation in the line or 1.25 times the maximum working pressure at the highest elevation in the line. In no case shall the test pressure be less than 50 psi.
4. Pressurization
 - a. Each valved section of pipe shall be slowly filled with water and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe. The pump pipe connection and all necessary apparatus, including gauges and meters shall be furnished by the Contractor. Before applying the specified test pressure, air shall be expelled completely from the test section. If permanent air release valves are not located at all high points, the Contractor shall install corporation cocks at all points so that the air can be expelled as the section is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test the corporation cocks shall be removed and plugged.
 - b. Any exposed pipe, fittings, valves, and joints shall be examined carefully during the test. Any damaged or defective pipe, fittings, valves, or joints that are discovered

following the pressure test shall be repaired or replaced with sound material and the test shall be repeated until it passes.

- c. Pressure test shall be maintained for a minimum of 2 hours.

5. Leakage Test

- a. After the completion of the pressure test, a leakage test shall be conducted to determine the quantity of water lost by leakage under the specified test pressure. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe or any valved section thereof to maintain pressure within 5 psi of the specified test pressure after the pipe has been filled with water and the air has been expelled.
- b. Leakage shall not be measured by a drop in pressure in a test section over a period of time.

6. Test all tracer wires to confirm continuity.

7. HDPE Pressure Pipelines-Pressure testing shall be conducted in accordance with requirements and recommendations of ASTM F 2164 (Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure), AWWA Manual of Practice M55 Chapter 9, and PPI Handbook of Polyethylene Pipe Chapter 2 (2nd Edition). Pneumatic (compressed air) leakage testing of HDPE pressure piping is prohibited for safety reasons.

- a. The section of pipe to be tested shall be filled with potable or generally clean water (uncontaminated river/lake water) approved by the Owner/Engineer. While the system is being filled with water, air shall be carefully and completely exhausted. If permanent air vents are not located at all high points, the Contractor shall install fittings and valves at such points so the air can be expelled as the pipe system is slowly filled with water.
- b. If the Contractor elects to perform hydrostatic testing against valves in an existing distribution system, it does so at his own risk and will bear the cost of any damages to the existing valve, piping system, private or public property, or the new pipeline under test.
- c. The test procedure for HDPE pipe consists of two steps: 1) the initial phase or expansion phase and 2) the test phase. During the initial/expansion phase, sufficient make-up water shall be added hourly for 3 hours to return to the test pressure. During the test phase, the expansion phase pressure is reduced by 10 psi to test phase pressure and monitored for at least one hour (3 hours maximum).
- d. Under no circumstances shall the total time under test exceed eight (8) hours. If the test is not completed due to leakage, equipment failure or any other reason, depressurize the test section and permit the system to "relax" for eight (8) hours prior to the next testing sequence.
- e. The test pressure should be related to the lowest point in elevation along the test section's vertical pipeline profile.
- f. The test pressure shall be 1.5 times the operating pressure at the lowest point in the system. In accordance with section 9.8 of ASTM F 2164, the pipe shall pass if the final pressure is within 5% of the test phase pressure for the testing period (3 hours maximum). If the test section fails this test, the Contractor shall repair or replace all defective materials and/or workmanship at no additional cost to the Owner.

D. Manholes

1. All manhole vacuum tests shall be conducted in the presence of a representative of the Utility and in accordance with ASTM C1244, Standard Test Method for concrete Sewer Manholes by Negative Air Pressure (vacuum) Test.
2. 100% of all manholes shall be tested.
3. The vacuum test equipment shall consist of: inflatable plugs for all incoming and outgoing sewer lines; an inflatable test collar to seal the manhole at the manhole frame; and a vacuum pump. A vacuum liquid filled gauge shall be located in-line between the test collar and the pump to accurately indicate the vacuum in inches of mercury within the manhole. The vacuum gauge shall have a minimum of 3.5 inch diameter face and a range to no more than thirty (30) inches of mercury, with scale markings of no greater than one-half (1/2) inch of mercury vacuum and an accuracy to within \pm two percent (2%) of true vacuum.
4. Preparation
 - a. Manholes shall be tested after installation with all connections in place.
 - b. Lift holes shall be filled with non-shrink grout, sealed and cured.
 - c. Manhole vacuum testing shall be performed after all adjacent underground utilities have been installed and all manholes have been completely backfilled and finished to grade. Vacuum testing prior to installation of all utilities may be considered upon request to the Utility prior to installation of all utilities if the manholes are completely backfilled and sewer leakage and deflection testing is complete. If vacuum testing is performed prior to all utilities being installed and any manholes are found to have been disturbed or damaged during inspection during the warranty period, the manholes shall be repaired and vacuum tested again to ensure that there is no leakage.
 - d. If a coating or lining is to be applied to the interior of the manhole, the test must not be performed until the coating is cured per manufacturer's recommendation.
5. Contractor shall submit to the Utility the results of each manhole vacuum test. Such reports shall include a description of the location of the manhole, the time, date and weather of the test, a list of all persons present, the diameter and depth of the manhole and the allowable test results, and the actual test results.
6. All manholes shall be repaired by Contractor and retested as described above until a successful test is made. After each test, the temporary plugs shall be removed.

E. Laterals

1. All laterals shall be visually inspected by a Utility representative.

2.

Table 1: SPECIFICATION TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015

1 PIPE DIAMETER (IN.)	2 MINIMUM TIME (MIN:SEC)	3 LENGTH FOR MINIMUM TIME	4 TIME FOR LONGER LENGTH (SEC.)	SPECIFICATION TIME OF LENGTH (L) SHOWN (MIN.:SEC.)							
				100 Ft.	150 Ft.	200 Ft.	250 Ft.	300 Ft.	350 Ft.	400 Ft.	450 Ft.
6	5:40	398	.854L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

Note: For more efficient testing of long test sections and/or sections of larger diameter pipes, a timed pressure drop of 0.5 psig may be used in lieu of the 1.0 psig timed pressure drop. If a 0.5 psig pressure drop is used, the required test time shall be exactly half as long as those shown above.

END