STANDARD WASTEWATER CONSTRUCTION SPECIFICATIONS

Town of Zionsville, Indiana

ZIONSVILLE

Town of Zionsville
1100 WEST OAK STREET
ZIONSVILLE, INDIANA 46077

June 2025

Lance Lantz, DPW Director

Table of Contents

Sections

SECTION 01001
GENERAL REQUIREMENTS

PART 1 – GENERAL

1.1 DEFINITIONS

A. Whenever used in these specifications the following terms have the meanings indicated which are applicable to both the singular and plural thereof:

1. Town - The Town of Zionsville, Indiana
2. ZDPW – The Zionsville Department of Public Works
3. Engineer - Town Engineer or designated representative
4. Owner or Developer - Person or firm having control of a development site and/or management of a project.
5. Contractor - The person, firm or corporation with whom the Owner or Developer has entered into an agreement for construction of the project.
6. Project - The total construction of which the work to be provided may be the whole or a part.
7. Work - The entire completed construction or the various separately identified parts thereof required to be furnished as part of a project.

1.2 REVIEW AND APPROVAL

A. Construction drawings and specifications must be stamped and signed by a registered Professional Engineer or Surveyor licensed in the State of Indiana, shall be approved by the Zionsville Department of Public Works (ZDPW), and be in accordance with these and all other applicable Town standards and specifications before construction begins.

B. A pre-construction meeting between the Contractor and Town is required prior to the commencement of any construction field activities.

C. All costs and fees of the Town Engineer, or his or her designated representative, for reviewing plats, development plans, construction documents, field inspections of improvements or installations of infrastructure or any other aspects of Subdivision or Development review, shall be the responsibility of and paid by the Developer.

1.3 SAFETY

The Contractor shall be solely responsible for the Safety of the worksite during the completion of the work.

1.4 DISCOVERY OF HAZARDOUS MATERIAL

If, during the course of the work, the existence of hazardous material, including asbestos containing material, is observed in an area that is to become property of the Town, the Contractor and or Developer shall immediately notify the Town in writing. The Contractor or Developer shall remove, or mitigate to IDEM standards, the hazardous material prior to the Town accepting the area for ownership and maintenance.

A. Asbestos containing material includes transite pipe.

1.5 OPERATIONS WITHIN EXISTING RIGHT-OF-WAY

A. The Contractor shall obtain a Construction in the Right-of-Way permit from the Town for all work to be performed within existing Right-of-Way.

B. All operations of the Contractor, including those of temporary nature, must be confined within the applicable right-of-way or easement limits after having obtained approval of the Town. If the methods of the construction employed by the Contractor are such as to require the use of land beyond the public right-of-way or easements, he shall make his own agreements with the property owners affected for the use of such additional areas.

C. Once streets, curbs and sidewalks have been inspected and accepted for use, any damage from construction work, including but not limited to tracked equipment, backhoe outriggers, water tap construction, sump pump line construction, fuel and oil spills, or carelessness by employees of the contractor, or any subcontractors and material suppliers, must be repaired (to the satisfaction of the Town) at the contractor's expense.

D. Streets must be kept clear of debris, construction materials (stone, sand, etc.) and erosion sediment on a daily basis. This includes mud deposited on the street as a result of vehicles leaving the construction site.

E. If necessary, the developer and/or Town representative will notify the builder to thoroughly clean the street, including any adjacent street areas that have been "dirtied" as a result of construction activities at a particular building site. If the street is not cleaned by a given date, the Town may clean the street and backcharge the contractor or developer.

F. Maintaining Traffic

1. Before closing any thoroughfare, the Contractor shall notify and, if necessary, obtain a permit or permits from the duly constituted public authority having jurisdiction; state, county, or town.

2. The Contractor shall notify the Town and other applicable agencies of his intention to close a particular street a minimum of 72 hours in advance of the proposed closing. The Contractor shall place all proper detour signs and barricades prior to the actual street closing.

3. During the construction, the Contractor shall be responsible for maintaining and protecting the pedestrian and vehicular traffic at all times, on all streets involved, and providing access to all residential and commercial establishments adjacent to the construction area. The Contractor shall furnish and maintain signage, barricades, flares, etc., in accordance with Indiana Manual on Uniform Traffic Control Devices. The signage, barricades, etc., must be in good condition.

4. The Contractor shall conduct his work in such manner as not to unduly or unnecessarily restrict or impede normal traffic through the streets of the community. Insofar as it is practicable, do not locate excavated material and spoil banks in such manner as to obstruct traffic. Keep the traveled way of all street, roads, and alleys clear and unobstructed insofar as is possible. Do not use streets, roads, or alleys for the storage of construction materials, equipment supplies, or excavated earth, except when and where necessary. If required by the Town, the Contractor shall, at his own expense, provide temporary crossing structures over trenches so as not to unduly restrict traffic. Such structures shall be of adequate strength and proper construction and shall be maintained by the Contractor in such manner as not to constitute a traffic hazard. Private driveways shall not be closed, except when and where necessary, and then only upon sufficient advance notice to the property owner and for the shortest practicable period of time, consistent with efficient and expeditious construction. The Contractor shall be liable for any damage to persons or property resulting from his work.

5. Streets in which excavation has occurred shall be temporarily restored to receive traffic as soon as possible. Permission to close additional streets shall be denied if, in the opinion of the ZDPW, the restoration on streets where excavation has occurred has not progressed satisfactorily.

6. The Contractor, when required, shall make provisions at cross streets for the free passage of vehicles and foot passengers, either by bridging or otherwise. Do not obstruct the sidewalks, gutters, or streets, or prevent in any manner the flow of water in streets. Use all proper and necessary means to permit the free passage of

surface water along the gutters. The Contractor shall immediately remove all offensive matter, exercising such precaution as may be directed by the Engineer. All material excavated shall be disposed of so as to inconvenience the public and adjacent tenants as little as possible, and to prevent injury to trees, sidewalks, fences, and adjacent property of all kinds. The Contractor may be required to erect suitable barriers to prevent such inconvenience or injury.

7. The Contractor shall place sufficient warning lights and arrow boards on or near the work and keep them illuminated during periods of construction and reduced visibility (from twilight in the evening until sunrise) and shall be held responsible for any damages that any party or the Owner may sustain in consequences of neglecting the necessary precaution in prosecuting this work.

1.6 ADDITIONAL PERMITS

A. The Developer or Contractor is required obtain permits by applicable federal, state and local agencies with jurisdiction related to the proposed project. Also, applicable licenses from other entities which have facilities affected by or crossed. These may include, but are not limited to, the following:

1. Indiana Department of Environmental Management
2. Indiana Department of Natural Resources and or FEMA
3. US Army Corps of Engineers
4. Indiana Department of Fire Prevention & Building Safety
5. Indiana Department of Transportation
6. Boone County Highway
7. Boone County Surveyor (drainage)
8. Railroad crossings
9. Gas or petroleum pipeline crossings
10. Utility Easement crossings

B. The Contractor shall obtain/possess all other applicable licenses or permits which relate to construction means and methods to be employed during the completion of the work.

1.7 DRAINAGE AND UTILITIES

A. All existing utility systems which conflict with the construction of the work shall be protected or relocated as required. The Developer and/or Contractor shall coordinate with the applicable utility as required. All proposed relocation work within the right-of-way shall be reviewed by the ZDPW for approval prior to completion.

B. New developments shall have dedicated sump pump and foundation drain collection systems with connection points at each lot within dedicated easements or the right-of-way. This system shall be separate from the required street underdrains under the curbs. Sump pumps must not surface discharge into streets or curbs.

C. Downspouts should not be connected to the street underdrains under the curbs. Downspouts should surface discharge to the lawn area adjacent to the home or to dedicated sump pump and foundation drain systems.

D. All excavations within 5 feet of the back of curb must be backfilled with compacted granular material or flowable fill.

E. If the curb or street is undermined when making an excavation, the developer and Town representative must be contacted to inspect the excavation and approve the method of backfill. An inspection may also be made of the underdrain to determine if any damage has occurred. All costs to place compacted granular backfill, as well as costs for any curb, street, or underdrain repair associated with the undermining, will be the contractor's responsibility.

F. Drainage easements are to be provided in accordance with the Town's stormwater management ordinance.

1.8 SANITARY SEWER LOCATION AND EASEMENT REQUIREMENTS

A. All sanitary sewer facilities, both existing and proposed, shall be located to provide adequate access for maintenance and/or repair, and as follows:

1. New Sanitary Sewer

   a. New sanitary sewers shall be constructed within the public right-of-way unless directed otherwise by the Town.
   b. If the right-of-way is not of sufficient width to avoid the granular backfill requirements and the sewer is fifteen (15) inches or less in diameter, the sewer may be constructed outside, but within five (5) feet of, the right-of-way within a ten (10) feet wide exclusive sanitary sewer easement.
   c. Utilities may encroach into the exclusive sanitary easement, but only for perpendicular crossings (between 45° and 90°). Parallel encroachments (less than 45°) are prohibited without written permission from the Town.
   d. When construction within, or within five (5) feet of, the right-of-way is not possible (i.e. crossing undeveloped offsite areas, etc.), the sanitary sewer shall be located in an exclusive sanitary sewer easement and in such a location to provide adequate access for ease of maintenance and/or repair. The Town will determine if access is adequate.
   e. Sanitary Sewers shall not be located in rear yards or other inaccessible areas unless directed otherwise by the Town.

2. Existing Sanitary Sewers

a. The proposed development shall be configured in such a manner to provide adequate access to all existing sanitary sewers and manholes for ease of maintenance and/or repair. The Town will determine if the site configuration provides adequate access.

Acceptable locations for existing sanitary sewer facilities within proposed developments may be as follows:

i. Within common areas;
ii. Within proposed right-of-ways;
iii. Adjacent proposed right-of-ways provided the existing sanitary sewer is in, and remains in, an exclusive sanitary sewer easement; and/or
iv. Others as deemed acceptable by the Town

b. The proposed subdivision or development shall not be configured in such a manner that would cause existing sanitary sewer facilities to be located in rear yards or other areas determined to be inaccessible by the Town.

3. Lift Stations

a. Proposed Lift Stations shall be approved by the Town on a case-by-case basis.

4. Force Mains

a. Existing and proposed force mains shall be located per the same requirements as sewers.

5. Adjacent Waterbodies

a. 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.
b. Sanitary sewers, force mains, and laterals crossing existing or proposed lakes, ponds, and/or stormwater retention or detention areas (either wet or dry) are prohibited unless approved by the Town.

B. Easements

1. Sanitary Sewer Easements shall be dedicated and recorded solely for the benefit of the Town.
2. No building, structure, tree, landscaping or other obstruction shall be allowed to be placed, erected, maintained, or allowed to be within any easement dedicated to the Town.
3. Easement boundaries shall be shown on the plans, specifications, and plats as “Sanitary Sewer Easement” or “Exclusive Sanitary Sewer Easement” in lieu of “Utility Easement.” Platted common utility easements are

prohibited for sanitary sewer facilities unless approved by the Town.

4. The minimum permanent easement widths to be dedicated to the Town are as follows:

   a. For sanitary sewers less than twenty-four (24) inches in diameter:

Depth of Sewer	Minimum Width, feet
Up to and including 10 feet	20
Greater than 10 feet to and including 20 feet	30
Greater than 20 feet	40

   b. All sanitary sewers shall be centered in the easement. For those sanitary sewers constructed in the public right-of-way, the easement shall extend the distance outside the right-of-way necessary to provide the required easement width.

   c. If the sewer is located outside, but within five (5) feet of the right-of-way and is fifteen (15) inches or less in diameter, the exclusive easement is only required to be ten (10) feet wide. The remainder of the required easement width may be shown as a Drainage, Utility, and Sanitary Easement (DU&SE). For sewers greater than fifteen (15) inches in diameter, the easement width shall be as shown in the above table.

5. For sanitary sewers twenty-four (24) inches and larger:

   a. The easement width will be determined on a case-by-case basis, but shall not be less than a minimum of fifty (50) feet in width.

6. Lift Stations

   a. The easements for lift stations may, at the discretion of the Town, be modified on a case-by-case basis, if justified. At a minimum, the easement requirements for lift stations to be as shown on the lift station site standard drawing.

7. Except for perpendicular crossings utility companies are not allowed to use the sewer easements for the installation of their utility lines without the expressed written permission of the Town. If permission is granted, utilities shall agree to relocate or support their respective facilities, at no expense to the Town if the Town requires access to maintain or repair the sanitary sewer facility.

8. All site development and plan/profile sheets shall clearly identify sanitary sewer easements and the location of all existing and proposed utilities if known.

1.9 DUST, NOISE, WORK HOURS AND EROSION CONTROL

A. Dust shall be minimized by use of watering or other applicable means.

B. Noise shall be minimized by use of properly constructed and maintained

equipment provided with suitable mufflers, snubbers, and other sound attenuating devices and supports.

C. Work Hours

1. Per the Town Noise Ordinance Construction activities shall be restricted to 7:00 a.m. to 7:00 p.m. Monday through Saturday, unless otherwise approved by the Town.
2. For work requiring on-site inspection, Construction activities shall be restricted to 7:30 a.m. to 4:00 p.m. Monday through Friday. Should the contractor desire to work outside of those hours, additional inspection costs may be incurred and at least 72 hours notice is required.

D. Erosion shall be controlled in such manner that soil particles from the construction site are prevented from entering public waters or from being deposited on neighboring property, streets, and highways. See the Town Stormwater Technical Standards for additional requirements.

1.10 SUBMITTALS

A. The Contractor shall provide submittal (shop drawing) data to the Town a from the manufacturer and/or supplier of each and every specified material or manufactured equipment item to be incorporated into the work.

B. Each submittal shall include a statement from the Contractor indicating that they have reviewed the material to be in accordance with the applicable sections of the standards.

1.11 BONDS

A. In order for a Developer to record a Secondary Plat for a new subdivision prior to completion and acceptance of the new public infrastructure associated with said subdivision, Performance and Maintenance Bonds (or equivalent letter of credit) shall be provided. The requirements for the bonds shall be as described in the Town's Subdivision Control Ordinance (Municipal Code Chapter 193).

B. Performance and Maintenance Bonds shall be provided for all proposed public or private stormwater facilities in accordance with the Town's Stormwater Ordinance and Technical Standards.

C. Bonds shall also be provided for any Town sponsored projects as required by the contract documents.

1.12 RECORD DRAWINGS

A. Record Drawings and the associated Digital Data submittal shall be provided per the current version of the Town's Record Drawings and Digital Data Submittal Requirements.

END OF SECTION 01001

SECTION 02300
EARTHWORK FOR SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Preparation of subgrades for surface restoration.

2. Excavation and backfill of sanitary sewer trenches, including structure backfill.

1.2 DEFINITIONS

A. Authorized Additional Excavation – excavation below subgrade elevations or beyond indicated lines and dimensions as authorized by Engineer

B. Backfill – material used to fill an excavation

C. Borrow Soil – soil imported from off site for use as fill or backfill

D. Excavation – removal of material encountered above subgrade elevations and to lines and dimensions indicated

E. Fill – soil materials used to raise existing grades

F. Final Backfill – backfill placed over initial backfill to fill a trench

G. Flexible Pipe – pipe manufactured of polyvinyl chloride, polyethylene, high-density polyethylene, or other plastic materials

H. INDOT SS – Indiana Department of Transportation Standard Specifications

I. Initial Backfill – backfill placed beside and over pipe in a trench, including haunches to support sides of pipe

J. Pipe Bedding – material placed over excavated subgrade in a trench before laying pipe

K. Rigid Pipe – pipe manufactured of ductile iron, cast iron, concrete, steel or other metals

L. Rock – rock which cannot be excavated without the use of a power shovel greater than 1 cubic yard capacity, or other equivalent powered equipment. Also includes all stones having a volume of 0.50 cubic yards or more

M. Subgrade – surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below topsoil materials

N. Unauthorized Excavation – excavation below subgrade elevations or beyond indicated lines and dimensions without authorization by Engineer or Wastewater Superintendent

O. Utilities – underground pipes, conduits, ducts, and cables

1.3 SUBMITTALS

A. Product data

1. Geotextiles

2. Flowable fill, including design mixture.

B. Material Test Reports

1. Sieve analysis in accordance with AASHTO T27 and materials certifications in accordance with INDOT SS of each aggregate proposed for fill or backfill.

2. Classification according to ASTM D2487 of each borrow soil material proposed for fill and backfill.

3. Laboratory compaction curve according to ASTM D1557 for each on-site and borrow soil material proposed for fill and backfill.

C. Qualification data for geotechnical testing agency

D. Schedule of tests and inspections

E. Field test reports

1.4 QUALITY ASSURANCE

A. Qualifications of geotechnical testing agency:

1. Independent testing agency qualified per ASTM E329 to conduct soil materials and rock-definition testing, per ASTM D3740 and ASTM E548.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory Soils

1. AASHTO M145 Soil Classification Groups A-1, A-2-4, A-2-5, and A-3, or a combination of these groups.

2. Satisfactory soils shall be free of rocks larger than 2” in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

3. Provide B borrow soil materials in compliance with INDOT SS when sufficient satisfactory soil materials are not available from excavations.

B. Unsatisfactory Soils

1. Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M145, or a combination of these groups.

2. Unsatisfactory soils also include satisfactory soils not maintained within 2% of optimum moisture content at time of compaction.

C. Impervious Fill

1. Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 OTHER BACKFILL AND FILL MATERIALS

A. Structure Backfill

1. No. 8 or No. 53 coarse aggregate per Section 904.03 of the INDOT SS.

B. Flowable Backfill

1. Flowable backfill per Section 213 of the INDOT SS.

C. Engineered Fill

1. Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand per ASTM D2940, with at least 90% passing a 1-1/2” sieve and 12% maximum passing a No. 200 sieve.

D. Filter Material

1. Coarse aggregate with 100% passing a 1” sieve and 0-5% passing a No. 4 sieve.

E. Sand

1. Fine aggregate, natural, or manufactured sand per ASTM C33.

F. Concrete Backfill

1. Class B concrete per Section 702 of the INDOT SS.

2.3 FILL FOR OVER-EXCAVATION

A. Fill for over-excavation, whether inadvertent or to obtain a stable bottom soil condition, shall be INDOT No. 8 crushed aggregate.

2.4 GEOTEXTILES

A. Geotextiles shall comply with Section 918 of the INDOT SS.

2.5 SOIL TREATMENT MATERIALS

A. Soil treatment materials to achieve necessary compaction shall comply with Section 913 of the INDOT SS.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection

1. Protect structures, utilities, pavements, poles, fences, mailboxes, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

2. Movable items such as mailboxes may be temporarily relocated during construction. Place movable items back at their original location immediately after backfilling is complete unless otherwise indicated. Replace items that are damaged during construction.

3. Prior to excavation work, pothole or otherwise physically confirm location and depth of existing utilities to be exposed by excavation. Notify Engineer and Wastewater Superintendent immediately of any potential conflicts with existing utilities.

4. Hand-dig at all locations within 2 feet of utilities.

5. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.2 EXPLOSIVES

A. Do not use explosives.

3.3 EXCAVATION, GENERAL

A. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

2. Remove rock to lines and grades indicated without exceeding the following dimensions:

a. 24” outside of concrete forms

b. 6” beneath bottom of concrete slabs on grade.

c. 6” beneath pipe in trenches

d. 24” wider than pipe diameter or 42” wide, whichever is greater.

3.4 EXCAVATION FOR SANITARY STRUCTURES, VAULTS, AND TANKS

A. Excavate to indicated elevations and dimensions indicated within a tolerance of plus or minus 1”. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services, and inspection.

B. Do not disturb bottom of excavations intended as bearing surfaces.

3.5 EXCAVATION FOR SANITARY SEWER TRENCHES

A. Excavate trenches to indicated lines, depths, and elevations.

1. Trench curves for flexible pipe shall not be less than the minimum radius of curvature recommended by pipe manufacturer.

B. Excavate trench walls vertically from trench bottom to 12” above top of pipe elevation, unless otherwise indicated.

1. Horizontal clearance of trench shall be 12” plus pipe diameter or 24” wide, whichever is less.

C. Excavate trench bottoms to provide uniform support of bedding course and pipe. Remove projecting stones and sharp objects along trench subgrade.

D. Fill over-excavations with suitable material to the indicated lines and grades.

3.6 SUBGRADE INSPECTION

A. Notify Engineer when excavations have reached required subgrade.

B. If unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed. Notify Engineer immediately if unsatisfactory subgrade soil is encountered during trench excavation.

C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavations under sanitary sewer pipe as directed by Engineer.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

B. Stockpile soil materials away from edge of excavations. Do not store within drip line of trees.

3.9 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Survey locations of underground utilities for record documents.
2. Test and inspect underground utilities where indicated prior to backfill.
3. Remove concrete formwork.
4. Remove trash and debris.
5. Remove temporary shoring and bracing and sheeting.

B. Place backfill on subgrades free of mud, frost, snow, or ice. Use topsoil removed during site clearing as final layer of backfill in areas to be restored with grass.

3.10 TRENCH BEDDING AND BACKFILL

A. Over-excavation

1. Place material in over-excavation on soils free of mud, frost, snow, or ice to indicated lines and grades. Notify Engineer upon restoration of trench bottom and obtain acceptance before proceeding with pipe installation.

B. Pipe Bedding

1. Place pipe bedding in trenches on firm subgrades free of standing water, mud, frost, snow, or ice.
2. Place and compact pipe bedding on trench bottoms. Shape pipe bedding to provide continuous support for bells, joints, and barrels of pipes.

C. Initial Backfill

1. Place and compact initial backfill to a height of 12” over the pipe.
    a. Carefully hand place and compact initial backfill in lifts no greater than 6” in depth under pipe haunches to springline. Compact each lift evenly on both sides and along the full length of pipe by shovel slicing, hand tamping, and walking the backfill in.
    b. Place and compact remaining initial backfill in lifts to avoid damage or displacement of pipe.
2. Where indicated, place flowable backfill to a height of 12” over the pipe.

D. Final Backfill

1. Place and compact final backfill to final subgrade elevation.
2. Place backfill so that it flows into the trench without freefalling.
3. Backfilling with satisfactory soil:

a. Mechanically tamp each lift until no further settlement is observed before placement of the next lift.

b. Heavy equipment shall not be used until there is at least 3 feet of cover depth over the pipe.

c. Leave trench surface in slightly rounded condition.

d. Maintain slightly rounded condition until surface restoration activities are initiated, but not less than 30 days.

4. Backfilling with structure backfill:

a. Mechanically tamp each lift until no further settlement is observed before placement of the next lift.

5. Unstable trench walls

a. With Engineer's prior approval, where trench walls become unstable during compaction, Contractor may push final backfill from the back of the trench into the trench and compact with vibratory compactor in 2 foot diagonal lifts.

6. Do not jet backfill.

E. Special Conditions

1. For trenches excavated under footings, place utilities in Schedule 40 PVC casing pipe and fill to 18" beyond either side of footings with Class B concrete to elevation of bottom of footings.

2. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

3.11 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.12 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate backfill soil lift and each subsequent fill or subgrade lift before compaction to within 2% of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2%.

3.13 COMPACTION OF SOIL BACKFILL AND FILL

A. Place backfill and fill soil materials in lifts not more than 8" in loose depth for material compacted by heavy compaction equipment, and not more than 4" in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly and uniformly on all sides of structures to required elevations.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D1557:

1. Under structures, scarify and recompact top 12” of existing subgrade and each lift of backfill or fill soil material at 95%.

2. Under walkways, scarify and recompact top 6” below subgrade and compact each lift of backfill or fill soil material at 92%.

3. Under unpaved areas, scarify and recompact top 6” below subgrade and compact each lift of backfill or fill soil material at 85%.

4. For trenches with structure backfill, compact each lift of initial and final backfill material at 95%.

3.14 GRADING

A. Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to lines and elevations indicated.

1. Provide a smooth transition between existing grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Slope grades to direct water away from structures and to prevent ponding.

3.15 FIELD QUALITY CONTROL

A. Engage a qualified independent geotechnical engineering testing agency to perform field quality control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill lift. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Testing agency will test compaction of soils in place according to ASTM D1556, ASTM D2167, ASTM D6938, and ASTM D2937, as applicable. Tests shall be performed at the following locations and frequencies:

1. Trench Structure Backfill

a. For final backfill, conduct 1 test for each manhole run or every 400 feet, whichever is shorter.

D. When testing agency reports that subgrades, fills, or backfills have not achieved the compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required. Recompact and retest until specified compaction is obtained.

3.16 PROTECTION

A. Protect newly graded areas from freezing and erosion and keep free of debris.

B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, or settled.

1. Scarify or remove and replace soil material to depth as directed by Engineer. Reshape and recompact.

C. Repair and re-establish grades where compaction is lost due to construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Engineer. Reshape and recompact.

D. Where settling occurs, remove finished surface, backfill with additional soil material, compact, and reconstruct surface.

1. Restore appearance, quality, and condition of finished surface to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.17 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off site.

END OF SECTION 02300

SECTION 02320
SPECIAL CROSSINGS - TRENCHLESS CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Furnish and install by trenchless construction methods casing and carrier pipes beneath streets, highways and railroads and do related work necessary to complete work shown or specified.

1. Horizontal directional drilling installation shall be per Section 02410.

B. Codes, specifications and standards referred to by number or title shall for a part of this specification to the extent required by the reference thereto. Latest revisions shall apply to all cases.

C. Abbreviations: ASTM - American Society for Testing and Materials.

1.2 PERMITS

A. The Contractor shall comply with the requirements of any permits that have been obtained for the completion of the work.

B. If permits were obtained based on the installation methods and materials shown on the plans and in this specification, should the Contractor desire to utilize an alternate installation plan, their preconstruction submittal shall provide a suitable description for review and approval by the Engineer, Owner and Permitting Agency. The Contractor shall also pay for any additional permit review fees as needed for the revised approval.

1.3 REQUIREMENTS

A. Performance Requirement: The Contractor shall determine equipment, materials and methods subject to the limitations specified herein. It is the responsibility of the Contractor to safely construct the crossing and provide the finished product within the requirements specified and shown.

B. The Owner and other involved agencies shall review and may modify, as necessary, the scheduling of any or all construction activities in order to prevent interruption of traffic or service.

C. In the performance of the Work, CONTRACTOR shall comply with the lawful requirements of the affected railway companies, public agencies, and owners of public utilities or other facilities for the safeguarding of traffic and improvements which might be endangered by the construction operations. Approach trenches in public streets will not be permitted to remain open for extended periods of time while work is not in progress.

1. Railroad crossings shall comply with Norfolk & Southern specification NSCE-8 or other applicable requirements of the affected railroad.

2. Crossings of State Highways and Interstates shall comply with Indiana Department of Transportation Specifications 716 latest addition.

D. All work shall be done in a careful, workmanlike manner to the satisfaction of both agency officials and the Owner.

1.4 QUALIFICATIONS

A. Experience: The Contractor shall have at least five (5) years experience in the construction of work of a similar nature.

B. The Contractor shall have successfully installed at least three (3) similar structures under heavy highway and/or railroad traffic.

1.5 SUBMITTALS

B. Pre-construction: Submit to the Owner the following a minimum of four (4) weeks before the scheduled start of the applicable activity:

1. Qualification Documents: For all key personnel, submit written documentation as supporting evidence of the qualifications. Key personnel shall include the foreman, office engineer, superintendent, and safety officer.

2. Installation Plans: Plan sheets on 11in. x 17in. or larger paper showing the location, dimensions and elevations of launching and receiving pits and equipment layout in relation to pertinent site features, including right-of-way lines, edge of pavement, existing pipe structures, existing utilities and any known potential obstructions.

3. Methods: A detailed description of the trenchless pipe installation method to be used for each pipe structure, including:

   a. A description of the methods for controlling the line and grade
   b. A description of the method to be used for grouting the annular space between the bored hole and the casing pipe or the casing pipe and the carrier pipe, as applicable
   c. The plan for penetrating, removing or otherwise managing obstructions, if encountered
   d. The plan for dewatering, if required, including the method of controlling erosion and sediment from dewatering operations
   e. The plan for ensuring that all voids created by trenchless pipe installation operations are filled in a timely manner
   f. The plan for monitoring surface settlement or heave, including the response plan for unacceptable settlement or heave

4. Pipe Jacking Thrust Calculations: Design calculations demonstrating that the pipe is capable of sustaining the maximum stresses to be imposed during jacking with a factor of safety of at least three. The calculations shall take into account maximum ground load combinations, live loads, jacking forces, grouting pressures, eccentric forces due to steering, external loads such as traffic, and any other loads which may be reasonably anticipated.

5. Materials: A list of all materials to be used and their dimensions, certifications and sources for each pipe structure including, but not limited to, the following:
   a. Casing pipe
   b. Carrier pipe
   c. Grout
   d. Bentonite or other lubricants
   e. Slurry mixes
   f. Casing spacers or blocking
   g. Fill for annular space

6. Equipment: A list of each piece of equipment to be used for each pipe structure. The equipment manufacturer's operation manuals shall be provided upon request.

7. Schedule: A critical path schedule of all trenchless construction activities.

C. Construction: Submit the following to the owner during construction within the time limitations stated.

1. Written daily logs: The Contractor shall maintain a log of the casing route. A copy of this log shall be submitted to the Owner after the completion of the crossing. The log shall also contain the following information for each crossing.
   a. The date, the starting time, and the finishing time.
   b. The position in relation to reference line and grade.
   c. The jacking force exerted on the pipe.

2. Record Drawings: The contractor shall submit a record drawing at the end of the installation including plan and profile views and vertical and horizontal deviations, indicating the relation to the planned path.

3. Comply with all applicable health and safety reporting requirements and provide copies of reports as required by public authorities to the Owner within 24 hours following preparation and submittal to third party authority. These reports are for record purposes only.

PART 2 - PRODUCTS

2.1 STEEL CASING PIPE

A. Casing pipe and joints shall be of steel construction, capable of withstanding the jacking installation loads as well as the load of railroad roadbed, track and traffic or the loads of pavement, subgrade and traffic, as applicable. The casing pipe and joints shall be watertight and constructed to prevent leakage of any matter from the casing or conduit throughout its entire length, except at open ends of the casing. The joints between sections of pipe shall be fully welded around the entire circumference of the pipe. Welded joints for the casings under a state highway shall be welded in conformance with INDOT specification 711.32 (latest edition).

B. The casing pipe shall be electric fusion, arc-welded steel pipe, new and unused material, in accordance with ASTM A-139 Grade B, with a minimum yield of 35,000 psi. The

inside diameter shall be at least six (6) inches greater than the largest diameter of the carrier pipe joint.

C. Steel casings shall be a minimum diameter of at least 6" greater than the biggest diameter of the carrier pipe and the minimum thickness indicated on the table below. The contractor may select a slightly different diameter as required for the method of work or a greater thickness to withstand the jacking loads to be imposed on the pipe during construction and to meet the installation tolerances given in this section. The minimum wall thickness of the casing pipe shall be as shown in the following table:

	Wall Thickness (in)	
Diameter of Casing	Under Highway	Under Railroad
18" or Smaller	0.250	0.312
20"	0.312	0.344
24"	0.375	0.375
30"	0.500	0.469
36"	0.500	0.532
42"	0.500	0.625
48"	0.5625	0.688
52"	0.625	0.750
54"	0.625	0.781

D. The interior and exterior walls of casing shall be coated with protective coal tar epoxy or bitumastic material. After the welding of each joint has been completed, coating shall be applied to any unprotected areas.

2.2 GROUT

A. Grout shall be used for filling the void between the casing pipe and the soil. Grout shall be Terra-Fill 100 mix or equal and conform to ASTM C495-83. Grout shall have a minimum compressive strength of 250 psi. The grout shall be fluid enough to inject through the grout holes and fill the entire void along the circumference of the casing. However, it shall set promptly enough to keep grout under control.

2.3 CARRIER PIPE CASING SPACERS

A. Casing spacers shall be manufactured of stainless steel and polyethylene, manufactured by Cascade Waterworks or approved equal.

PART 3 -EXECUTION

3.1 CONSTRUCTION OF CASING PIPE

A. The casing operation and installing shall proceed from a pit, excavated at a safe distance from the edge of the highway or railroad, and be constructed without interruption to highway or rail traffic.

B. Excavation for pits shall be sheeted as necessary to provide safe working conditions and protection for track, highway, roads, structures and utilities. Pits are to be backfilled

when installation is complete. Excavation and backfilling shall be as specified in Section 02300, Earthwork.

C. Where ground water is known or anticipated, and where the technique selected for trenchless pipe installation does not provide positive support at the trenchless excavation face, such as by slurry support in microtunneling, then trenchless pipe installation shall not proceed without dewatering in advance of trenchless pipe installation. A dewatering system of sufficient capacity to handle the flow shall be maintained at the site until its operation can be safely halted. The dewatering system shall be equipped with screens or filter media sufficient to prevent the displacement of fines.

D. Pavement or ground surface heave or settlement resulting in damage to pavement, existing utilities, or structures above the installation will not be permitted. To confirm if heave or settlement is occurring, the Contractor shall undertake surface monitoring.

E. Contractor shall control the application of the jacking pressure and excavation of materials ahead of the casing as it advances to prevent the casing from becoming earthbound or deviating from the required line and grade. Contractor shall restrict the excavation of the materials to the least clearance necessary to prevent binding in order to avoid loss of ground and consequent settlement or possible damage to overlying structures. If voids develop or if the bored diameter is greater than the outside diameter of the pipe by more than 1" – grouting shall be used to fill such voids. Allowable deviations in horizontal and vertical alignments shall be as given in this specification.

F. The ends of the casing shall be suitably protected against the entrance of foreign material by sealing with a double row of brick. Use bitumastic or vinyl sealing compound in lieu of mortar.

G. If an obstruction is encountered during installation which stops the forward progress of the pipe, and it becomes evident that it is impossible to advance the pipe, the Engineer shall be notified. For installations utilizing tunnel shields or tunnel boring machines or other methods that allow access to the face, the obstruction shall be removed in accordance with the contractor's work plan. For installations utilizing methods that do not allow access to the face, at the direction of the Engineer, the pipe shall be abandoned in place and filled with grout or other approved materials.

H. Remove all excavated material and replace or repair existing structures or utilities encountered to the satisfaction of the Town.

3.3 INSTALLATION OF CARRIER PIPE

A. The carrier pipe shall be installed inside a casing pipe at the elevations and grades shown on the plans within the tolerances described in Section 3.5.

B. The carrier pipe designated on the drawings shall be as specified in the appropriate section for the type of carrier pipe, i.e., water main, gravity sanitary sewer, storm sewer, force main or electrical conduit.

C. Jointing of the carrier pipe shall be as specified in the appropriate Section for the type of pipe material and joint fittings.

D. Place the carrier pipe into and through the casing at locations shown on plans. Employ suitable methods to maintain tight joints. The carrier pipe shall be tested in accordance with the testing requirements for that pipe type as given in the appropriate specification section.

E. Casing spacers or wood blocking shall be used to center the carrier pipe inside the casing. Casing spacers or blocking shall be spaced a maximum of 4 feet on center for PVC carrier pipes and 6 feet on center for ductile iron. Wood blocking shall be either redwood or pressure treated fir. Wood blocking shall be secured using stainless steel straps.

F. Unless otherwise specified on the drawings, once the casing pipe is installed, fill the space between the carrier pipe and casing pipe with sand cement cellular grout. Terra-fill 100 mix or equal.

3.4 CLOSING OF PITS

A. After jacking equipment and excavated materials from the boring or jacking operations have been removed from the jacking pit, Contractor shall prepare the bottom of the jacking pit as a pipe foundation. Contractor shall remove loose and disturbed materials below pipe grade down to undisturbed earth and shall re-compact the material in accordance with Section 02300.

3.5 ALIGNMENT AND TOLERANCES

A. Generally, the pipes shall be installed within acceptable tolerances such that the constructed pipeline is in an acceptable location and can connect with the proposed pipelines at either end so that the final complete pipeline hydraulically functions as intended. If line or grade adjustments are required to the upstream or downstream pipe segments to accommodate an alignment deviation, it shall be made at no additional cost.

B. The casing pipe for the gravity sewer pipe installations shall be installed to maintain the minimum cover and clearances as shown on the plans and to allow for the carrier to be installed per the following tolerances:

1. The carrier pipe at either end of the casing shall be within 0.5 ft of the elevations shown on the plans and must be straight along its entire length with a minimum grade of 0.4%.

C. The casing pipe for the water main and force main pipe installations shall be installed to maintain the minimum cover and clearances as shown on the plans.

D. The horizontal alignment of the installed casing shall be within 2 feet of the alignment indicated on the plans and shall not cause a pipe to be installed within the required separation distances between water and sewers.

END OF SECTION 02320

SECTION 02410
HORIZONTAL DIRECTIONAL DRILLING

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes requirements for pipe installation using the horizontal directional drilling method.

1.2 DEFINITIONS

A. HDD – Horizontal Directional Drilling.

1.3 SUBMITTALS

A. Product data for drilling fluid and admixtures, MSDS sheets, and manufacturer's literature.

B. Shop Drawings

1. Scaled and dimensioned plan and profile layouts of pipe.

    a. Drawing submittal shall show finished grades, deflection and radius of the pilot bore, and all existing utilities with minimum vertical and horizontal clearances. Proposed clearances shall exceed the guidance system accuracy tolerance by a minimum of 100% for flexible pipe and 150% for rigid pipe.

2. Locations of proposed pits and equipment set-up areas.

C. Qualification Data

1. Name, address, and phone number of any subcontractor proposed for the HDD work.

2. Name and phone number of 5 references to contact to verify similar projects.

3. List of completed projects.

4. Names and work history of all supervisory field personnel to be present during HDD work.

5. Qualifications records certifying that fusion bonding operators employed to complete fusion bonding are qualified to install flexible pipe.

D. Field Test Reports

1. Calibration records for guidance equipment.

E. Manufacturer's Instructions

1. Bonding Procedure Specification for installing flexible pipe. Shall include cutting and facing requirements.

F. Project Record Documents

1. Drilling logs

1.4 QUALITY ASSURANCE

A. Qualifications

1. Contractor Experience

    a. Contractor or subcontractor shall have the following minimum requirements in horizontal directional drilling:

        1. 5 horizontal directional drilling projects of a similar nature.

        2. Successful completion of at least 50,000 linear feet of directional drilling. Conventional open cut trenching shall not be considered applicable experience.

2. Supervisory personnel shall be adequately trained and shall have at least 4 years of experience in directional drilling.

3. Fusion bonders and bonding operators shall be qualified in the use of the Bonding Procedure Specification.

PART 2 - PRODUCTS

2.1 PIPE

A. The pipe to be used shall be High Density Polyethylene (HDPE) as specified in Section 02545 and shall be suitable for use in directional drilling installations.

2.2 DRILLING FLUID

A. Drilling fluid shall be composed of clean water and appropriate additives such as bentonite clay and polymer admixtures specifically blended for use in drilling.

B. Water shall be from a clean source with a pH of 8.5 – 10 or in accordance with mixing requirements of the additive manufacturer. Water of a lower pH or with excessive calcium shall be treated with sodium carbonate or equal.

C. No hazardous additives may be used. Drilling fluid shall be totally inert and contain no risk to the environment.

D. Drilling fluid shall be maintained at a viscosity sufficient to suspend cuttings and maintain the integrity of bore wall.

2.3 TRACER WIRE

A. Shall be as described in Section 02545 – Sanitary Force Mains.

2.4 TRACER WIRE BOXES

A. Shall be as described in Section 02545 – Sanitary Force Mains.

PART 3 - EXECUTION

3.1 EQUIPMENT

A. Directional drilling equipment shall consist of:

1. A directional drilling rig of sufficient capacity to perform the bore and pull back the pipe.

2. A drilling fluid mixing and delivery system of sufficient capacity to successfully complete the drilling and pulling.

3. A guidance system to accurately guide boring operations.

B. Drilling Rig

1. The directional drilling machine shall consist of a hydraulically powered system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head.

2. The machine shall be anchored to the ground to withstand the pulling, pushing, and rotating pressure required to complete the crossing.

3. The hydraulic power system shall be self-contained with sufficient pressure and volume to power drilling operations. Hydraulic system shall be free of leaks.

4. Rig shall have a system to monitor and record maximum pull-back pressure during pull-back operations.

5. A magnetic or walk-over guidance system shall be able to control the depth and direction of the pipe and must be accurate to within 6".

C. The drill head shall be steerable by changing its rotation and shall provide the necessary cutting surfaces and drilling fluid jets for effective use in the soils being bored.

D. Drilling fluid motors shall be of adequate power to turn the required drilling tools.

E. Guidance System

1. Electronic walk-over guidance system, magnetic guidance system probe, or proven gyroscopic probe and interface.

2. Provide a continuous and accurate determination of the location of the drilling head during the drilling operation, including all depths up to 50 feet and in any soil condition, including hard rock.

3. Enable the driller to guide the drill head by providing immediate information on the tool face, azimuth (horizontal direction), and inclination (vertical direction).

4. Accurate and calibrated to manufacturer's specifications for the vertical depth of the bore hole at sensing position at depths up to 50 feet and accurate to at least 2 feet horizontally.

5. The operator shall be aware of any magnetic anomalies and shall consider such influences in the operation of the guidance system.

F. Pipe Rollers

1. Pipe rollers, if required, shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull-back operations.

2. Provide enough rollers to prevent sagging of pipe.

G. Pipe Rammers

1. Hydraulic pipe rammers, pneumatic pipe rammers, and other devices providing horizontal thrust other than those defined in the preceding sections shall not be used unless approved by the Engineer and Wastewater Superintendent prior to commencement of pipe boring.

H. Other Equipment

1. Drilling fluid mixing system shall be a self-contained, closed system of sufficient size to mix and deliver drilling fluid.

2. Mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing.

3. Drilling fluid reservoir tank shall be sized for adequate storage of the drilling fluid, but no less than 1,000 gallons.

4. Mixing system shall continually agitate the drilling fluid during drilling operations.

5. Drilling fluid pumping system shall have a minimum capacity to supply fluid in accordance with the drilling equipment pull-back rating at a constant required pressure of no less than 1,200 psi.

6. Drilling fluid delivery system shall have filters in-line to prevent solids from being pumped into the drill pipe. Connections between the pump and drill pipe shall be leak-free.

7. Drilling rig shall be fitted with a permanent alarm system capable of detecting an electrical current. This system shall have an audible alarm to warn the operator when the drill head is nearing electrified cables but is still at a safe distance.

8. Pipe bonding equipment shall be in proper operating condition. Equipment heater shall be tested and certified prior to use for fusion bonding.

3.2 DIRECTIONAL DRILLING PROCEDURE

A. Notify Engineer and Wastewater Superintendent 48 hours before initiating HDD operations.

B. Site Preparation

1. Grade or fill site to provide level work area. No alteration beyond what is required for operations shall be made. Limit activities to designated work area.

C. Drill Path Survey and Layout

1. Accurately survey entire drill path.

2. If a magnetic guidance system is used, survey drill path for any surface geomagnetic variations or anomalies.

3. Contact all property owners regarding the location of all existing service lines, water wells, septic tanks, etc.

4. Contact all utilities to determine the location of all existing underground lines, cables, pipes, valves, vaults, etc.

5. Excavate and confirm location and elevation of existing utilities in or near path of HDD work.

6. Maintain a continuous positive grade of the pipe toward air relief valve locations and a continuous negative grade of the pipe away from air relief valve locations, with only one low point between air relief valve locations. Avoid high spots in the line between air relief valve locations.

7. Where conflicts occur with existing utility lines, the pipe layout may be shifted to avoid interference with the existing utility lines. All location changes shall be limited to existing easements and rights-of-way. Note on layout plan all proposed changes in pipe location.

8. Drilling depths below 96” shall not be allowed without permission from the Engineer and Wastewater Superintendent.

9. Drilling above a depth of 54” shall not be allowed without permission from Engineer and Wastewater Superintendent.

10. Prepare a dimensioned, scaled plan for submittal to Engineer.

D. Environmental Protection

1. Place silt fence between all drilling operations and any drainage areas, wetlands, waterways, or other areas designated for such protection by state, federal, and local regulations. Additional protection necessary to contain drilling fluid spills shall be put in place, including berms, liners, turbidity curtains and other measures. Adhere to all applicable environmental regulations.

2. Used or spilled drilling fluid shall be contained and properly disposed of. A spill sock, hay bales, or sandbags shall be maintained around drill rigs, drilling fluid mixing system, entry and exit pits, and drilling fluid recycling system to prevent spills into the surrounding environment. Provide pumps or vacuum trucks to remove excess drilling fluid from containment areas.

3. Spoils shall be promptly recovered by use of a vehicle-mounted vacuum system. Spoils are not to be discharged into sewers or storm drains. Dispose of all spoil and excess excavated material in accordance with applicable regulations.

E. Pilot Hole

1. Pilot hole shall be drilled on bore path with no deviations greater than 5% of depth over a length of 100 feet. In the event the pilot hole deviates from the bore path more than 5% of depth in any 100 feet, notify Engineer. Unless directed otherwise, pull-back and re-drill from a location along the bore path before the deviation.

2. If a drilling fluid fracture, inadvertent returns, or returns loss occurs during pilot hole drilling operations, cease drilling, wait at least 30 minutes, inject drilling fluid with a viscosity exceeding 120 seconds as measured by a Marsh funnel, and then wait another 30 minutes. If drilling fluid fracture or returns loss continues, cease operations and notify Engineer.

F. Reaming

1. Upon successful completion of pilot hole, ream bore hole to a minimum of 25% greater and a maximum of 50% greater than outside diameter of pipe using the appropriate tools. Do not attempt to ream more than the drilling equipment and drilling fluid system are designed to safely handle.

2. The type of hole opener or back reamer used shall be based on the types of subsurface soil conditions encountered.

3. Drilling fluid shall remain in the tunnel to increase stability of the tunnel and to provide a lubricant to reduce drag when the pipe is pulled.

G. Setup

1. Pipe will be placed on pipe rollers before pulling into bore hole. Rollers shall be spaced close enough to prevent sagging of pipe.

2. Contractor may pre-test pipe prior to pulling. However, pre-testing is not a substitute for the acceptance testing otherwise required.

3. The interior of every pipe, fitting, and valve shall be cleaned of all debris, dirt, and other foreign material before being bonded and shall be kept clean until work is completed.

4. Install polyethylene encasement on ductile iron pipe during pipe setup or when pulling pipe according to installation Method A in accordance with AWWA C105 for installations below the water table.

H. Tracer Wire

1. Shall be installed as described in Section 02545 – Sanitary Force Mains.

I. Pull-back

1. After successfully reaming bore hole to the required diameter, Contractor will pull the pipe through the bore hole.

2. Pipe will be elevated to the approximate angle of entry and supported to allow a straight, smooth pull.

3. Once pull-back operations have begun, operations must continue without interruption until pipe is completely pulled into the bore hole. During pull-back, do not apply more than the maximum safe pipe pull pressure at any time.

4. If pipe becomes stuck, cease pulling operations to allow any potential hydro-lock to subside. If pipe remains stuck, notify Engineer and Wastewater Superintendent.

J. Valves, Fittings, and Appurtenances

1. Install services, pipe connections, fittings, valves, and other appurtenances where indicated in accordance with applicable specifications.

K. Recordkeeping

1. As the pilot hole is drilled, measure location and depth of the pilot hole. Record readings after advancement of each successive drill pipe (no more than 10 feet).

   a. Plot on a scaled drawing of 1” = 2’, both vertical and horizontal.

   b. Tabulate and record coordinates on the record drawings daily.

   c. Access to all records and plan and profile information shall be made available to Engineer and Wastewater Superintendent at any time.

2. Do not allow the deflection radius of the drill pipe to exceed the deflection limits of the carrier pipe as specified by the pipe manufacturer.

3. Maintain a daily log of drilling operations and a guidance system log.

END OF SECTION 02410

SECTION 02530
GRAVITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes gravity flow, (non-pressure) sanitary sewers, including:

1. Sanitary sewer mains.
2. Sanitary sewer laterals.
3. Sanitary manholes.

B. Related regulations include the following:

1. 327 IAC 3-6 Technical Standards for Sanitary Collection Systems.

1.2 DEFINITIONS

A. AWWA – American Water Works Association

B. HDD – horizontal directional drilling

C. INDOT SS – Indiana Department of Transportation Standard Specifications

D. PVC – polyvinyl chloride plastic

E. HDPE – high-density polyethylene

F. DI – ductile iron

G. HDPE – high density polyethylene

H. MJ – mechanical joint

I. SS – stainless steel

1.3 SUBMITTALS

A. Prior to Installation, the Contractor shall provide the following information:

1. Product data for:
    a. Pipe, joints, and fittings.
    b. Tracer wire and warning tape.
    c. Manhole castings.
    d. Manhole products including boots and gaskets, sealants, joint sealing products, and infiltration control products.
2. Shop Drawings
    a. Precast manhole structures.
3. Product Warranties

B. Project Record Documents shall be in accordance with the Town's Record Drawing and Digital Data Submittal Requirements

1.4 QUALITY ASSURANCE

A. Pipe shall be new, free of defects, and shall meet all applicable specification requirements.

B. Manholes – shall be new, free of defects, and meet the requirements of ASTM C478

C. Regulatory Requirements

1. Comply with requirements of Wastewater Superintendent.

2. Comply with standards of authorities having jurisdiction for sewer-service pipe, including materials, installation, and testing.

3. Comply with requirements of IDEM and EPA regarding wastewater facilities.

1.5 SYSTEM REQUIREMENTS

A. Design Requirements

1. Provide the services of a registered Professional Engineer to design flat top slabs for manholes per ASTM C478, or for flat top slabs located in the right-of-way.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic components, pipe, gaskets, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle pipe and manholes according to manufacturer's written rigging instructions.

D. Do not skid or roll products on or against other products.

E. Stacking of pipe shall meet the requirements of the pipe manufacturer.

F. Do not allow gaskets to come in contact with petroleum products.

1.7 PROJECT CONDITIONS

A. Do not interrupt sewer service or sewer flow unless permitted under the following conditions, and only after providing temporary sewer service:

1. Notify Engineer and Wastewater Superintendent no fewer than 2 days in advance of proposed service interruption.

2. Do not proceed with interruption of sewer service without Wastewater Superintendent’s written permission.

3. Comply with requirements of Town Wastewater Department in providing temporary sewer service.

PART 2 - PRODUCTS

2.1 GENERAL

A. Special Applications and Limitations

1. PVC and HDPE sewer pipe shall be used in buried locations only.

2. Horizontal Directional Drilling of Laterals

a. Shall be as described in Section 02410 – Horizontal Directional Drilling.

3. Boring and Jacking Pipe Installations

a. Water Quality Pipe shall be used for the carrier pipe.

2.2 PVC GRAVITY SEWER PIPE

A. General

1. Pipe and fittings shall have an integral bell and spigot rubber gasket joint and smooth inner walls.
2. Solvent cement joints shall not be allowed.
3. Pipe and fittings shall be colored green for identification as wastewater pipe.

B. PVC Pipe and Fittings

1. Pipe 15” or less shall meet ASTM D3034.
   a. Pipe installed at a depth of 16 feet or shallower shall be SDR 35.
   b. Pipe installed at depths greater than 16 feet shall be SDR 26.
2. Pipe in sizes larger than 15” through 48” shall meet ASTM F679.
   a. Pipe installed at a depth of 16 feet or shallower shall be PS46.
   b. Pipe installed at depths greater than 16 feet shall be PS115.
3. Minimum tensile strength of 34.50 MPa per ASTM D1784.
4. Minimum pipe stiffness of 46 psi for SDR 35 and 115 psi for SDR 26 when measured at 5% vertical ring deflection tested per ASTM D2412.

C. Joints

1. Joints shall be flexible gasket compression-type conforming to ASTM F477.
2. Joint performance shall be in accordance with ASTM D3212 under both pressure and 22” Hg vacuum.
3. Joints and couplings connecting to dissimilar pipe or fitting types shall be in accordance with both manufacturers’ recommendations.

D. Fittings

1. Fittings shall conform to ASTM D3034.
   a. Fittings installed at a depth of 16 feet or less shall be SDR 35.
   b. Fittings installed at depths greater than 16 feet shall be SDR 26.

2.3 WATER QUALITY PIPE

A. General

1. Joints connecting to dissimilar pipe or fitting types shall be in accordance with manufacturer’s recommendations.

B. Water Quality PVC Pipe

1. Pipe and fittings shall be colored green for identification as wastewater pipe.
2. Pipe and fittings shall have an integral bell and spigot rubber gasket joint and smooth inner walls.
3. MJ Ductile Iron Fittings may be used for PVC Pipe connections.

4. SDR Series Pipe and Fittings
    a. SDR series pipe shall conform to ASTM D2241, SDR 21 (200 PSI rating).
    b. Fittings shall meet the same standards as the pipe.
5. AWWA Series Pipe
    a. Pipe shall conform to AWWA C900, DR 18 (235 PSI rating).
    b. Fittings shall meet the same standards as the pipe.

C. Water Quality Ductile Iron Pipe
1. Pipe shall conform to AWWA C151.
2. Pressure class in conformance with AWWA C150:
    a. Pipe sizes through 12” shall be 350 psi pressure class.
    b. Pipe sizes greater than 12” shall be 250 psi pressure class.
3. Joints
    a. Buried Service
        1) Mechanical joints per AWWA C110 and AWWA C111.
        2) Push-on type joints shall conform to AWWA C111.
        3) Gaskets meeting AWWA C111.
4. Coatings
    a. Interior to have Protecto 401 lining.
    b. Outside asphaltic coating shall meet the requirements of AWWA C151.
    c. Interior and exterior coatings shall be provided for all pipe and fittings.
5. Encasement
    a. Polyethylene encasement colored green and conforming to AWWA C105.

D. Fittings for AWWA Series Pipe and DI Pipe
1. Fittings shall be DI meeting the requirements of AWWA C110.

2.4 WARNING TAPE

A. General
1. Warning tape shall be made of inert materials, resistant to alkalis, acids, and other destructive agents found in soil.
2. Warning tape shall have a minimum thickness of 4 mils.
3. Warning tape width shall be a minimum of 3” and a maximum of 6”.
4. Imprint shall repeat a minimum of once every 2 feet of tape length.
5. Warning tape shall be aluminum-backed or have a foil core detectable by a cable locator.

B. Material
1. Warning tape shall be imprinted with “CAUTION – SANITARY SEWER BURIED BELOW” or similar wording.

2. Tape shall be green in color or green striped with black printed lettering.

C. Warning tape shall be Terra Tape Diamond Detachable by Reef Industries, Inc., or approved equal.

2.5 TRACER WIRE

A. Tracer wire shall be annealed copper-clad high carbon steel or solid copper.

B. Insulation shall be HDPE complying with ASTM D1248, 30-volt rating. Insulation shall be Green in color.

C. Composite conductivity shall be 21% IACS (International Annealed Copper Standard).

D. Minimum physical characteristics:

1. AWG: 10

2. Insulation thickness: 0.030”

E. Connectors shall be from manufacturer’s packaged kit, consisting of insulating spring-type connector or crimped joint and epoxy resin moisture seal, suitable for burial.

2.6 TRACER WIRE BOXES

A. General

1. Cylindrical construction with removal round lid.

2. Support flange at the base at least 1/2” wide.

a. If box is designed for use with integral valve support, flange may be omitted.

3. Telescoping design with upper and lower tubes overlapping 3” when the box is extended to its maximum length.

4. Magnetized to amplify tracer signal.

a. A magnet shall be securely attached on the upper inside of the box or encapsulated within the lid.

B. Material

1. Box material shall be high grade ABS or equivalent rigid plastic that meets ASTM D1788, Type 1.

2. Lid material shall be cast iron or ductile iron, with tensile strength or ductility meeting ASTM A126-B.

C. Box Lid

1. Colored green for wastewater per APWA standards.

2. Lock with a tamper-resistant pentagon locking nut.

3. Internal corrosion-resistant brass wire lug for tracer wire connection, and a wax pad to block out moisture at the wire connection.

D. Manufacturer

1. Tracer wire boxes shall be:

a. Snakepit Lite Duty Access Point by Copperhead Industries in unpaved areas.

b. Snakepit Roadway Access Point by Copperhead Industries in paved areas.

c. Or approved equal.

2.7 PRECAST MANHOLES

A. General

1. Precast reinforced concrete manhole sections shall be manufactured in accordance with ASTM C478. Concrete shall be minimum 28-day compressive strength of 4,000 psi.

2. Thickness and Design

   a. Manhole sections less than 6 feet in diameter shall have a minimum wall thickness of 5".

   b. Continuous steel hoop reinforcement shall not be used except with Engineer's prior approval.

   c. Flat slab tops shall be designed according to:

      1) ASTM C478 if located outside of the right-of-way.

      2) AASHTO M 199M/M 199 if located within the right-of-way.

   d. Where depth exceeds 12 feet, provide 2 cages of reinforcement per ASTM C76 (assume structure as a Class III reinforced concrete pipe of the same diameter).

3. Hoisting lugs or hooks shall be cast in place for handling and setting. No through-the-wall lift holes are allowed.

4. Openings of proper sizes and suitable design shall be cast in place or core drilled for receiving pipes and connections.

   a. "Doghouse" manholes shall only be allowed on a case-by-case basis as approved by the Town.
   b. No manhole opening shall be broken or chiseled into the structure (all holes must be clean and smooth).

5. Manhole diameter indicated is minimum. Provide larger diameter manholes where a minimum distance between penetrations cannot meet the following requirements:

   a. 12" for non-cored openings.

   b. 8" for cored openings.

6. Provide supplemental reinforcing to the primary reinforcing cage at all penetrations 12" or larger in diameter.

7. Precast concrete items shall not exhibit cracks, voids, or other visible imperfections, evidence of imperfect proportioning, mixing, or molding, or visible reinforcing steel.

8. All precast manhole items, including adjusting rings, used on any particular manhole, shall be provided by the same manufacturer.

9. Precast manhole sections shall be steam or hot water mist cured and shall not be installed until at least 5 days after having been cast.

B. Manhole Joints

1. Precast Manhole Sections

   a. Joints shall be tongue and groove with rubber gaskets per ASTM C443.

b. Supplementary joint sealer shall conform to Federal Specification SS-S-210.

c. Exterior joint collars shall conform to ASTM C877, Type II.

2. To seal adjusting rings and casting frame, provide butyl mastic or trowelable joint sealer in extrudable 1/2" preformed cords, per Federal Specification SS-S-210.

C. Base Sections

1. Base sections for shall be constructed with the base and first riser section as one complete integral precast unit.

2. Benches

a. Benches may be precast or cast-in-place into base section.

b. Use 3,500 psi minimum 28-day compressive strength concrete for cast-in-place benches.

c. Brushed finish to prevent slipping.

d. Slope toward the channel not less than 1" per foot.

3. Flow Channels

a. Channels shall be smooth, continuous, u-shaped in cross section, with constant width and invert grade from inlet to discharge.

b. Changes of flow direction shall be made with a smooth curve with the maximum possible radius.

c. For cast-in-place flow channels, provide a minimum of 3" from the top of the base slab to the invert out.

4. Bedding

a. Manhole base bedding shall be INDOT No. 8 crushed aggregate.

b. Over-excavation, whether inadvertent or to obtain a stable soil condition, shall be filled as specified in Section 02300 – Earthwork for Sanitary Sewers.

D. Pipe Connections

1. Pipe connectors shall comply with ASTM C923.

2. Rubber sleeve with stainless steel banding installed in factory. Stainless steel elements of the connector shall be totally non-magnetic Series 305 SS.

3. Rubber compression gasket cast into section.

4. For pipes less than 18" in diameter, pipe connector shall be Kor-N-Seal 106/406 Series flexible boot connector as manufactured by Trelleborg Pipe Seals, Z-Lok boot connector as manufactured by A-Lok Products, Inc., or approved equal.

5. For pipes 18" and greater in diameter, pipe connector shall be Kor-N-Seal 206 Series flexible boot connector as manufactured by Trelleborg Pipe Seals, Z-Lok STM boot connector as manufactured by A-Lok Products, Inc., or approved equal.

E. Cone Sections

1. Eccentric cone type.

2. Provide uniform circumference on top 4" for external chimney seal.

F. Flat Tops

1. Precast flat tops shall be 8” thick minimum and designed for the loading noted in 2.7.A.2.C.

G. Outside Drops

1. Outside drops can be:
    a. Precast with manhole sections.
    b. Field constructed with Engineer and Wastewater Superintendent’s prior approval.
2. Precast outside drops shall comply with requirements for manhole sections.
3. Field Constructed Outside Drops
    a. Comply with sewer pipe requirements for drop pipe.
    b. Use only rubber compression gasket cast-in-place for pipe connections.
    c. Encase in concrete, minimum 28-day compressive strength of 4,000 psi.

H. Adjusting Rings

1. Adjusting rings shall be precast concrete conforming to ASTM C478.
2. Nominal thickness shall be between 3” and 6”.
3. Total height of all adjusting rings used on each manhole shall not exceed 12”.

I. Castings

1. General
    a. Castings shall be manufactured in accordance with ASTM A48, Class 35B with a minimum tensile strength of 35,000 psi.
    b. Castings shall be of uniform quality and free of all defects.
    c. Casting shall be manufactured true to pattern. Component parts shall exhibit a good fit and be interchangeable. Horizontal bearing surfaces shall be machined and not experience rocking or rattling under traffic or other loads.
    d. Castings shall be well cleaned by shot blasting or other methods.
2. Standard frames and lids.
    a. 1022Z1 by East Jordan Iron Works, Neenah R-1772, with solid self-sealing lid and concealed pickholes.
    b. Or approved equal.
3. Bolt-down gasketed frames and lids.
    a. 1022Z1 PT by East Jordan Iron Works, with solid boltdown lid and gasket.
    b. Or approved equal.

J. External Joint Wrap

1. External joint wrap shall comply with ASTM C877.
2. Shall be External Joint Wrap by Cretex Specialty Products, or approved equal.

K. External Chimney Seal

1. External chimney seal shall be a single continuous rubber band meeting the material requirements of ASTM C923.
2. Seal shall be able to extend as one piece from cone section to casting frame.
3. Attachment shall be with a minimum of 2 16-gauge type 304 stainless steel bands with type 304 SS accessories.
4. Shall be External Manhole Chimney Seal by Cretex Specialty Products or approved equal.

L. Exterior Coating

1. The exterior of all manholes shall have a spray applied solvent free waterproof membrane. ConSeal CS-1800 or equal.

2.8 CAST-IN-PLACE MANHOLES

A. Cast-in-place manholes may only be used with prior approval of Engineer and Wastewater Superintendent. The design engineer shall provide appropriate specification data as required.

2.9 CONNECTIONS TO EXISTING MANHOLES

A. Manhole wall penetration seals shall be either:

1. Rubber sleeves complying with ASTM C923.
2. Link-Seal Model S-316 or equal.

B. Internal Drops

1. Drop pipe size, material, and fittings to match main line for gravity sewers.
2. Use force main pipe material with restrained joints or flange joints for force mains.
3. Use Type 304 SS braces and anchor fixtures.
4. Shall utilize Inside Drop Bowl by Reliner/Duran Inc. or approved equal.

C. Structural Repair Grout

1. Shall be designed to fill large voids in structure walls.
    a. All joints between cement repairs shall be sealed with a hydrophilic water stop.
2. Shall consist of rapid setting cements, aggregates, and various accelerating agents.
3. Shall not contain chlorides, gypsum, or metallic particles.
4. Shall have a minimum compressive strength of 1,400 psi at 6 hours per ASTM C109.
5. Shall be Quadex Hyperform by Vortex Co., Strong-Seal QSR by The Strong Company, or approved equal.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of pipe systems used to estimate wastewater flows, size pipe and calculate friction loss, pump sizing, and other design considerations. Install pipe as indicated unless deviations to layout are approved by Engineer and Wastewater Superintendent.

B. See specification 02300 Earthwork for sanitary sewers for excavation, bedding, and backfill requirements.

C. Install pipe beginning downstream, true to grade and alignment indicated with unbroken continuity of invert. Place bell ends of pipe facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturers. Comply with ASTM D3212 for joint tightness.

D. Sanitary sewers shall be laid at least 10 feet horizontally and 18" vertically from any existing or proposed water main, measured edge to edge. Notify Engineer if this separation cannot be met. Installations within this distance, if allowed, will require water quality pipe.

E. As sanitary sewers are installed, lines shall be marked with a 2"x4" or other acceptable stake, with a minimum height of 3 feet above grade. Stake shall have the uppermost section painted green to indicate sewer line placement.

F. Install manholes at all changes in pipe direction or pipe grade.

G. Lateral Connections

1. Material and construction requirements for mainline sewers shall apply to sewer laterals.
2. Use fittings for lateral connections to sanitary sewers.
3. Saddle taps may only be used to connect laterals to existing sewers.
    a. Connect laterals to existing sewers only with Engineer and Wastewater Superintendent's prior written approval.
4. Laterals shall be installed from a wye or tee fitting in the main sewer line to the property line or easement line unless otherwise indicated.
5. Intrusion of service connections into the main line sewer shall not be permitted.
6. Laterals shall connect to main sewer line at a maximum angle of 45 degrees from the spring line and shall include any bends necessary to reach the property line at the elevation specified.
7. Tracer wires are to be installed with all sewer laterals.

H. Install proper size couplings according to manufacturer's instructions where different sizes or materials of pipes and fittings are connected.

I. Reducing size of pipe in direction of flow is prohibited.

J. Install gravity sewer pipe according to the following:

1. Meet or exceed minimum slope required by regulatory authorities.
2. Install ductile iron gravity sewer pipe and fittings per AWWA C600, ASTM A746, and AWWA M41.
3. Install PVC sewer pipe per ASTM D2321, ASTM F1668, and AWWA M23.
4. Blocking pipe up to grade and then bedding under it is prohibited. The entire length of the bed section is to be at proper grade before installing pipe.
5. Provide a waterproof bulkhead at points of connection to the existing sewer system from the time of the connection until the new sewers have been completed and cleaned of all debris.
6. Use a laser beam for horizontal and vertical control of the sewer.

a. Set up laser unit so that the alignment of the beam is through the centerline of the pipe or outside the pipe directly above and parallel to the centerline of the pipe. Confirm elevation at regular intervals along pipe segment using survey equipment.

b. If set up on the centerline:

1) Provide a blower for continuous air circulation within the pipe.

2) Establish a target on line and grade to provide a method of checking the setting of the laser beam as construction progresses.

c. If set up above the pipe:

1) Provide means to ensure the grade pole is plumb when checking pipe grade.

2) Set grade pole on the invert of the pipe when checking alignment and grade.

K. Install pipe encasement over DI pipe and fittings per ASTM A674 or AWWA C105.

L. Clear interior of pipe and manholes of dirt, water, and superfluous material as work progresses. Place plug in end of incomplete pipe when work stops.

M. Field Cut Pipe

1. Per manufacturer's recommendations.

2. Bevel end by grinding or filing as close to the original taper provided by the manufacturer as possible.

3.2 PIPE JOINT CONSTRUCTION

A. Join PVC sewer pipe per ASTM D2321 and ASTM D3034 for elastomeric-seal joints or elastomeric-gasket joints.

B. Join DI gravity sewer pipe per AWWA C600 for push-on joints, and per AWWA C600 or AWWA M41 for special fittings or DI fittings.

C. Join dissimilar pipe materials with non-pressure type, flexible couplings according to both pipe manufacturer's directions.

3.3 INSTALLATION OF WARNING TAPE

A. Warning tape shall be installed over all buried non-metallic pipe in accordance with manufacturer's installation instructions.

B. Warning tape shall be installed 12" above the pipe centerline unless noted otherwise on plans.

3.4 INSTALLATION OF TRACER WIRE

A. Provide a tracer wire on all lateral pipes.

B. Wire shall commence at the main and be installed along the lateral pipe.

C. Terminate tracer wires above ground at each cleanout.

D. Individually test each tracer wire strand after installation. The wire shall shall provide continuous transmission of tracing signal along the full pipe length.

3.5 MANHOLE INSTALLATION

A. Manholes shall be installed straight and plumb. Completed manholes shall be rigid, true to dimensions, and watertight.

B. Bottom of excavation shall be flat, level and dry, with stable soils, prior to manhole installation. Place and level stone base prior to manhole installation. Fill over-excavation with INDOT No. 8 crushed aggregate prior to bedding.

C. Install and compact pipe bedding from bottom of manhole to pipe bottom elevation prior to making pipe connection to manhole.

D. Place backfill evenly around manhole to prevent lateral movement.

E. In general, top of casting elevations given are approximate. Unless a top of casting elevation is specifically indicated to differ from this requirement, field adjust all castings to the following elevations:

1. Set tops of frames and covers +0” to -1/4” with finished surface for manholes located in paved surfaces.

2. Set tops of frames and covers 3” above finished surface elsewhere.

F. Where manhole is within a legal drain or FEMA designated floodway, or where shown on the plans, manhole frames and lids shall be bolt-down type.

G. Install adjusting rings and frame according to manufacturer’s recommendations and the following:

1. Clean the concrete cone or top slab to assure a flat seating surface free of debris.

2. Install adjusting rings of thickness necessary to come within 1/4" of grade with the cover frame in place, considering the space between the adjusting rings created by the compressed joint sealer.

3. Apply two strips of joint sealant to each joint from the top of the cone or slab to the casting frame. Install joint sealant around the entire circumference, overlapping the ends.

4. Install adjusting rings centered over eccentric cone top, straight and plumb. Reset when knocked offline.

5. Set the casting frame in place, centered on the top adjusting ring.

6. Frames shall be bolted through the anchor base flange to the cone section with 3/8" stainless steel anchor bolts, washers, and concrete anchors.

H. Chimney Seals

1. Exterior chimney seals shall be installed according to manufacturer’s directions.

I. Manhole Backplaster

1. Apply backplaster evenly at a minimum thickness of 1/4” from the frame to 2” below the last adjusting ring.

2. Install wrap over backplaster, covering the backplaster completely.

J. Manholes Receiving Force Main Discharge

1. Coat inside to prevent deterioration by sewer gases.

2. Clean casting and concrete surface to remove dirt, loose concrete, and cement.

3. Apply one coat of Tnemec 46H-413 or approved equal to interior concrete surfaces and all casting surfaces to 16 mils to 20 mils thickness.

3.6 CONCRETE PLACEMENT

A. Place concrete external to manhole according to ACI 318/318R.

B. Place cast-in-place concrete manholes and cast-in-place bases in precast manholes according to ACI 350/350R.

3.7 ABANDONING SANITARY SEWER SYSTEMS

A. Where new sewers replace existing sewers, abandon existing sewers only after completion of construction, testing, and acceptance of new sewers. Connect existing customers to new sewers prior to abandoning existing sewer.

B. Abandoned Pipe: Method to be used shall be approved by the Town.

1. Abandonment by Removal

    a. Remove and dispose of all pipe to be abandoned.

    b. Fill excavation with final backfill as defined in Section 02300 – Earthwork for Sanitary Sewers.

2. Abandonment by Capping

    a. Clean pipe to be abandoned using high pressure jetting.

    b. Close open ends of underground pipe to be abandoned with plastic plugs, concrete, or other acceptable methods. Do not use wood plugs.

3. Abandonment by Filling

    a. Clean pipe to be abandoned using high pressure jetting.

    b. Pump flowable fill into the sewer pipe from one manhole to the next. Flowable fill shall be as defined in Section 02300 – Earthwork for Sanitary Sewers.

    c. Fill until visually apparent at the opposite end that all space within the pipe has been filled.

C. Abandoned Manholes

1. Abandonment by Filling

    a. Break 2 holes (minimum of 12” diameter) in manhole barrel at bench elevation.

    b. Remove top of manhole down to at least 36” below final grade.

    c. Fill manhole to within 12” of top of remaining manhole structure with stone, sand, or gravel.

    d. Fill excavation with final backfill per Section 02300 – Earthwork for Sanitary Sewers.

2. Abandonment by Removal

    a. Excavate and remove manhole.

    b. Fill excavation with final backfill per Section 02300 – Earthwork for Sanitary Sewers.

3.8 CONNECTIONS TO EXISTING MANHOLES

A. Make connections from sewers to existing manholes by core drilling a clean circular opening into existing manhole of the size required for the pipe connector. Saw cutting and hammer taps

are prohibited without Engineer and Wastewater Superintendent's prior written approval. Install pipe connector into manhole, and install pipe through connector according to manufacturer's instructions.

B. Cut end of connection pipe passing through pipe or structure wall to conform to be flush with inside wall, unless otherwise indicated.

C. Prevent concrete or debris from entering existing pipe and manholes while making connections. Remove debris or other material that may accumulate.

D. Reconfigure manhole bench and flow channel as required. Provide smooth transition into existing channel and bench. Use structural repair grout to form new channel and bench.

3.9 FIELD QUALITY CONTROL

A. Testing, General

1. Test new pipe systems and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
    a. Inspect and test completed pipe systems.
    b. Schedule inspections and tests with Engineer and Wastewater Superintendent with at least 48 hours advance notice.
    c. Submit separate report for each test.
2. Failure of inspections or tests indicate defects that must be repaired or replaced.
3. Replace failed work using new materials and repeat testing until test results are within allowances specified.

B. Cleaning

1. Conduct standard cleaning prior to acceptance testing. All foreign debris, rocks mud, etc. shall be removed from the pipe and manhole system.

C. Mandrel Deflection Test

1. Conduct deflection tests on PVC or other flexible pipe sewers using a mandrel.
2. Mandrel Characteristics
    a. Mandrel manufactured for the purpose of determining flexible pipe deflection shall have a diameter of at least 95% of the base pipe ID indicated in the applicable pipe standard.
    b. Minimum mandrel length shall be as follows:
        1) 8" long for 8" diameter pipe.
        2) 10" long for 10" diameter pipe.
        3) 10" long for 12" diameter pipe.
        4) 12" long for 15" diameter pipe.
        5) As approved by Engineer for pipe larger than 15".
    c. Mandrel shall be made of steel or aluminum and have 9 or more arms.
    d. Provide proving ring clearly marked with diameter and ASTM standard.
3. Procedure

a. Conduct tests a minimum of 30 days after the backfill has been placed to final grade.

b. Pull the mandrel through all main line sewers.

c. The pipe shall pass the deflection test if one person can pull the mandrel through the pipe by hand.

4. Any pipe that does not pass the deflection test shall be replaced and retested at no additional expense to the Town.

D. Closed-Circuit Television Inspection

1. All sections of sewers shall be inspected by closed circuit television.

2. The Contractor shall clean the sewer prior to completing the CCTV Inspection.

3. All unacceptable conditions found during television inspection must be corrected by the Contractor and re-televised.

4. Unacceptable conditions are conditions that adversely affect the ability of the system to function as designed or to be properly maintained and may include, but are not limited to, the following:

a. Protruding taps

b. Cracked or faulty pipe

c. Misaligned or deformed pipe

d. Debris in line

e. Infiltration / exfiltration

f. Excessive gaps at joints

g. Bellies or sags with a depth greater than or equal to 10% (or a maximum of 1-1/2 inches) of pipe diameter and/or a length greater than 25 feet.

5. See Specification Section 02532 Sewer Televising for procedures.

E. Low Pressure Air Test

1. All main line sewers including attached laterals, shall be subjected to an air test.

2. Test shall comply with ASTM F1417.

3. Procedure:

a. The air test may be done after final backfill is placed in the trench.

b. At a minimum, the following equipment shall be provided:

1) Mechanical or pneumatic plugs.

2) Air control panel.

3) Shut-off valve, pressure regulative valve, pressure relief valve, and input pressure gauge. The pressure regulator or relief valve shall be set no higher than 9 psig to avoid over pressurization.

4) Continuous monitoring pressure gauge having a range of 0 to at least 10 psi. The gauge shall be no less than 4" in diameter with minimum divisions of 0.10 psi and an accuracy of ± 0.04 psi.

5) To reduce the potential for sewer line over-pressurization, 2 separate hoses shall be used to.

   a) Connect the control panel to the sealed line for introducing low pressure air; and

   b) Constantly monitor air pressure buildup in the line.

6) If pneumatic plugs are utilized, a separate hose shall be required for inflation.

c. The procedures for the low-pressure air test are as follows:

1) After a manhole-to-manhole segment of pipe has been backfilled to final grade and all laterals and appurtenances installed, securely place and brace suitable test plugs in the ends of the sewer segment and in all lateral stubs included in the test. All plugs shall be securely restrained and braced prior to and during the test.

2) Add air slowly to the test section until the pressure inside the pipe reaches 4.0 psig plus the necessary adjustment for groundwater (Initial Pressure). The air pressure adjustment for groundwater is:

   a) 2.0 psig unless groundwater monitoring wells have been installed.

   b) If groundwater wells or manhole groundwater monitoring taps have been installed, the adjustment shall be determined by the following:

      Adjustment = Depth of Groundwater x 0.43

      where:

      Adjustment = Adjustment added to the starting pressure of the low-pressure air test, psig. The maximum adjustment shall be 2.0 psig.

      Depth of Groundwater = As measured above the top of pipe, feet.

      0.43 = Conversion factor

      If more than one well was installed, take the average depth of the nearest downstream and nearest upstream monitoring locations.

3) Do not exceed 6.0 psig at any time during the low-pressure air test.

4) After the initial pressure is reached, the air supply shall be throttled to maintain that initial pressure for at least 2 minutes. This time permits the temperature of the entering air to equalize with the temperature of the pipe wall.

5) Testing

   a) When temperatures have equalized and the pressure stabilized at the initial pressure, the air hose from the control panel to the air supply shall be shut off or disconnected.

b) The continuous monitoring pressure gauge shall then be observed while the pressure is decreased to no less than 0.5 psig below the initial pressure. At this reading, or any convenient observed pressure reading between the initial pressure and 0.5 psig below the initial pressure, timing shall begin.

c) A timed pressure drop of 0.5 psig shall be used. The allowable time shall be predetermined using the following table.

TABLE 02530-1
SPECIFICATION TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED

Pipe Dia. (in)	Min. Time (min:sec)	Length for Min. Time (ft)	Time for Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	0.190L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	0.472L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	0.760L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	64:54
30	14:10	80	10.683L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926L	21:33	32:19	43:56	53:52	64:38	75:24	86:10	96:57
36	17:00	66	15.384L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23

6) No time adjustment will be made for lateral lengths.

7) If the time shown for the designated pipe size and length elapses before the 0.5 psig pressure drop, the section of pipe being tested shall have passed the test. The test may be discontinued once the prescribed time has elapsed even though the pressure drop has not occurred.

8) If the pressure drops 0.5 psig or more before the appropriate time has elapsed, the air loss rate shall be considered excessive, and the section of pipe being tested shall have failed the test.

9) Uncover, replace, or repair and completely retest any section of sewer or laterals not passing the test. The method of repair shall be subject to acceptance by Engineer. Grouting is not an acceptable method of repair.

F. Vacuum Test

1. All manholes shall be subjected to a vacuum test. The vacuum test shall include the sewer-to-manhole connection boot and all joints between the casting and the bottom of the base. Internal chimney seals shall be tested separately.

2. Testing shall be done per ASTM C1244.

3. If possible, each manhole shall be tested immediately after assembly and prior to backfilling. If the test is done after backfilling, Contractor shall be responsible for re-excavation to locate and correct any leaks that have been identified.

4. Equipment used shall be made specifically for vacuum testing of manholes.

5. Testing Procedures

a. All pipes entering the manhole shall be temporarily plugged, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole.

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

c. A vacuum of 4.9 psig shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off.

d. The time for the vacuum reading to drop from 4.9 psig to 4.4 psig shall be measured. The allowable time shall be determined by using the following table.

TABLE 02530-2

MINIMUM TIME REQUIRED FOR A PRESSURE RISE OF 1" Hg

FOR MANHOLES OF VARIOUS DEPTHS AND DIAMETERS

Manhole Depth to (ft.)	Diameter (in)		
	48	60	72
	Time (sec)		
8	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	65
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121
Add for each addn'l 2'	5	7	8

6. If the time shown for the designated manhole depth and diameter elapses before the vacuum reading drops by 0.5 psig, the manhole shall have passed the test.
7. If the vacuum reading drops more than 0.5 psig before the appropriate time has elapsed, the manhole shall have failed the test.
8. Uncover, replace, or repair the manhole and retest until a successful test is accomplished.

END OF SECTION 02530

SECTION 02541
SANITARY SEWER STRUCTURE REHABILITATION

PART 1 - GENERAL

1.1 SCOPE

A. This specification shall govern all work, materials, and equipment for restoring structural integrity, eliminating water infiltration, and providing corrosion protection in sanitary sewer manholes by applying various rehabilitation techniques as applicable and described in this section. This is to be completed per the manhole rehabilitation schedule included in the plans.

B. The Contractor shall furnish all labor, equipment, materials, and services for applying repair materials, per manufacturer's specifications, with machinery specially designed for the application. All aspects of the installation shall be in accordance with the manufacturer's recommendation and with the following specifications which includes:

1. The removal of any loose and unsound material.

2. Cleaning of the area to be sprayed with high pressure water.

3. The repair and filling of voids.

4. The repair and sealing of the benches.

5. The elimination of active infiltration prior to making the application.

6. The spray application of cementitious product to form a monolithic liner.

7. The spray application of epoxy liner protective coating.

8. The sealing of the manhole frame to the chimney section

C. The plugging of any manhole, which stops regular flow, shall only be allowed until the manhole upstream is approximately ¼ full. If the product cannot be applied in that time, by-pass sewage pumping shall be used in accordance with Section 02539 "Temporary Bypass Pumping". Any flooding of resident's basements shall be the sole responsibility of the Contractor. The Contractor shall make restitution with any affected property owner.

1.2 SUBMITTALS

A. Comply with the requirements of Section 01340 as well as requirements specified herein.

B. Product literature and technical data sheets on each product used, including ASTM test results indicating product conforms to and is suitable for its intended use per these specifications.

C. Material Safety Data Sheets (MSDS) for each product used.

D. Project specific installation guidelines and recommendations.

E. Installer Qualifications:

1. Manufacturer certification that the individual(s) performing actual material installation has been trained and approved in the handling, mixing, and application of the products to be used.

2. Certification by the manufacturer that the equipment to be used for applying the products has been approved and installation personnel have been trained and certified for proper use of the equipment.

3. Five (5) recent U.S. references from installer (projects of similar size and scope) indicating successful application of this system by method of application specified herein.

4. Proof of any federal, state, or local permits or licenses necessary for the project.

5. Design details for any additional ancillary systems and equipment to be used in site and surface preparation, application, and testing.

PART 2 – PRODUCTS

2.1 PATCHING MATERIAL

A. Mainstay ML-10 Hydraulic Cement Mortar; Sauereisen Underlayment F-120FS; Parson RPM; or equal, a quick setting cementitious material, shall be used as a patching material and is to be mixed and applied according to manufacturer's recommendations and shall have the following minimum requirements:

Compressive Strength (ASTM C109)	3,500 psi @ 1 day
	5,500 psi @ 28 days
Tensile Strength (ASTM C190)	290 psi @ 7 days
	575 psi @ 28 days
Shrinkage (ASTM C157)	0.04% @ 28 days

2.2 INFILTRATION CONTROL MATERIAL

A. Mainstay ML-10 Hydraulic Cement Mortar; Sauereisen InstaPlug F-180; Parson Quick Plug; or equal, a fast-setting product formulated for leak control, shall be used to stop minor water infiltration and shall be mixed and applied according to

manufacturer's recommendation and shall have the following minimum requirements as applicable:

Compressive Strength (ASTM C109)	3,500 psi @ 1 day 5,500 psi @ 28 days
Tensile Strength (ASTM C190)	290 psi @ 7 days 575 psi @ 28 days
Shrinkage (ASTM C157)	0.04% @ 28 days

2.3 GROUTING MIX

A. Avanti 118 Duriflex Acrylic Gel; Sauereisen Hydroactive Polyurethane Grout F-370; Spectra-Grout Source One Environmental-Hypoflex; Green Mountain International, Mountain Grout Ultron; or equal, shall be used for stopping very active infiltration and filling voids and shall be mixed and applied according to manufacturer's recommendations.

2.4 CEMENTITIOUS JOINT SEALING

A. Mainstay ML-72 Sprayable Microsilica Cement Mortar; Parson MH Liner; or equal shall be used to seal each manhole barrel joint on manholes designated for "Joint Sealing." The material used shall be mixed and applied per the manufacturer's recommendations.

2.5 FULL CEMENTITIOUS LINER

A. Mainstay ML-72 Sprayable Microsilica Cement Mortar; Sauereisen Substrate Resurfacer F-121; Parson MH Liner; or equal cementitious liner products shall be used to form a full structural monolithic liner covering all interior manhole surfaces and shall have the following minimum requirements:

Property	**Standard**	**Value**
Compressive Strength	ASTM C109	3,000 psi (@ 1 day) 10,000 psi (@ 28 days)
Tensile Strength	ASTM C496	330 psi (@ 1 day) 790 psi (@ 28 days)
Flexural Strength	ASTM C293	535 psi (@ 1 day) 1,400 psi (@ 28 days)
Shrinkage	ASTM C596	0.01%
Bond Strength	---	> 500 psi
Density, when applied	---	120 pcf

B. All products shall be reinforced with alkaline resistant materials.

C. Material shall meet or exceed industry standards and shall not have any basic ingredient that exceeds U.S. EPA maximum allowable limits for any heavy metal.

2.6 EPOXY LINER PROTECTIVE COATING

A. Mainstay DS-5; Sauereisen SewerGard 210-S; Parsonpoxy SEL-80; or equal, an epoxy coating shall be used to form a to monolithic liner to cover and protect all interior cementitious lined manhole surfaces subjected to municipal wastewater service conditions, including associated abrasive physical attack and chemical attack mechanisms related to hydrogen sulfide and organic acids generated by microbial sources and shall have the following minimum requirements:

Property	Standard	Value
Compressive Strength	ASTM D695	13,000 psi
Tensile Strength	ASTM D638	6,500 psi
Flexural Strength	ASTM D790	12,500 psi
Durometer Hardness	ASTM D2240	98

2.7 CHIMNEY SEALANT MATERIAL

A. Madewell 806 Flexible Joint Sealant; Sauereisen ChimneySeal F-88; Parsonpoxy FP; or equal, an elastomeric urethane material specifically designed to bond and seal between metallic manhole cover frame and lined (or unlined) manhole chimney sections shall be used to seal against backside water pressure or infiltration with application per manufacturer's recommendations

2.8 WATER

A. Shall be clean and potable. Questionable water shall be tested by a testing laboratory in accordance with ASTM C94. Potable water need not be tested.

2.9 EQUIPMENT

A. Applicator must use approved equipment specifically for the application of the product to be used.

PART 3 - EXECUTION

3.1 PREPARATION

A. The interior surfaces of each structure shall be cleaned with high pressure (7,000 psi minimum) water spray, using detergent, baking soda, antibacterial agent or other Engineer-approved chemicals until all grease, oil and other contaminants are removed.

B. Place covers over invert to prevent extraneous material from entering the sewer lines.

C. All foreign material shall be removed from the manhole wall, chimneys, frame, and bench using a high pressure water spray (minimum 7,000 psi). Loose and protruding concrete shall be removed using a mason's hammer and chisel and/or scraper. Fill any large voids with quick setting patching mix (Paragraph 2.01).

D. Active leaks shall be stopped using quick setting, patching mixes (Paragraphs 2.01, 2.02, 2.03) according to manufacturer's recommendations. Some leaks may require weep holes to localize the infiltration during the application after which the weep shall be plugged with the quick setting mix (Paragraph 2.02) prior to the final liner application. When severe infiltration is present, drilling may be required in order to apply pressure grout (Paragraph 2.03). Manufacturer's recommendations shall be followed when pressure grouting is required.

3.2 INTERIOR PATCHING

A. After all preparations have been completed, remove all loose material and wash wall again.

B. Any wall, bench, invert, or service line repairs shall be made at this time using the quick setting patching mix (Paragraph 2.02) and shall be used per manufacturer's recommendations.

C. Repairs shall be performed on all surfaces with visible damage or where infiltration is present or when vacuum testing is specified. After blocking flow through manhole and thoroughly cleaning, the quick setting patch material (Paragraph 2.02) shall be applied to all defects in an expeditious manner. The material shall be troweled uniformly onto the damaged area at a minimum thickness of ½ inch extending out sufficiently to tie into the structure. The finished surfaces shall be smooth and free of ridges. The flow may be re-established in the manhole within 30 minutes after placement of the material.

3.3 APPLICATION OF CEMENTITIOUS JOINT SEALANT

A. The substrate surface prior to application of the sealant shall be clean and must be free of all foreign material. Abrasive blast or mechanically abrade metal surfaces in accordance with SSPC-SP 6 Commercial finish. All protrusions shall be ground smooth to eliminate sharp edges.

B. Sealant may be applied in a single application or pass by trowel, or gloved hand in accordance with manufacturer's recommendations, to achieve a total minimum thickness of **1/2 inch.** After application the sealant shall be smoothed with a trowel or wet sponge.

C. The sealant shall be applied from 6 inches above the bottom of the each barrel section joint and extend 6 inches below the joint.

D. Allow a minimum of 24 hours for final cure before exposure to chemicals or water.

3.4 APPLICATION OF FULL CEMENTITIOUS LINER MATERIAL

A. Mixing:

1. For each bag of product, use the amount of water required by the manufacturer's recommendations following mixing procedures noted on product bag using only enough water to produce a mix consistency to allow application of liner material one-half (1/2) inch thick in a single application without material "sagging" on vertical surface and using approved equipment for mixing and application.

2. Prepared mix shall be discharged into a hopper and another batch prepared to occur in such a manner as to allow spraying continuously without interruption until each application is complete.

B. Spraying:

1. The surface prior to spraying shall be clean and must be free of all foreign material and shall be damp without noticeable free water droplets or running water, but totally saturated, just prior to application. Materials shall be spray applied a minimum of one-half (1/2) inch thick in one or more passes from the bottom of the manhole frame to the bench; however minimum total thickness shall not be less than **1/2 inch nor greater than 1 inch**. The surface is then troweled to a relatively smooth finish being careful not to over trowel.

2. A brush finish shall be applied to the trowel-finish surface. Manufacturer's recommendations shall be followed whenever more than 24 hours have elapsed between applications.

3. Bench Application: The wooden covers shall be removed at this time and the bench sprayed such that a gradual slope is produced from the walls to the invert with the thickness at the edge of the invert being no less than ½ inch. The wall/bench intersection shall be rounded to a uniform radius the full circumference of the intersection.

C. Curing:

1. Caution should be taken to minimize exposure of applied product to quick surface drying and air movement. If between application of addi-

tional coats is to be longer than 15 minutes, the manhole cover shall be set back in place. At no time should the finished product be exposed to sunlight or air movement for longer than 15 minutes before replacing the manhole cover. In extremely hot and arid climates, manhole should be shaded while reconstruction is in process.

2. The final application shall have the following minimum cure time before being subjected to active flow:

   a. Storm runoff & surcharge: 8 hours

   b. Force main impact: 12 hours

3. After final application, traffic shall not be allowed over manholes/structures for 6-8 hours after reconstruction is complete.

3.5 APPLICATION OF FULL EPOXY LINER PROTECTIVE COATING

A. Mixing: Epoxy liner is two component liquid system. All components should be between 70° F and 90° F prior to mixing. The entire contents of each component should be thoroughly mixed individually before combining separate components together. The premeasured quantities of both components should be poured into a clean container and blend thoroughly using a power agitator, such as a "Jiffy" type mixer and a high strength industrial drill, for five (5) minutes. Do not mix more material than can be used within stated working times.

D. Installation: Epoxy lining shall be applied by spray method to a minimum thickness of **60 mils** in a single application from the bottom of the manhole frame to the bench, including the bench and invert. Application should be done with a 50% overlap in a "cross hatch" pattern to reduce the possibility of pinholes and to assure complete coverage. Application equipment shall be approved by the Applicator, in accordance with the protective coating manufacturer's recommendations.

E. Curing: Allow a minimum of 8 hours prior to any top coating at a temperature of 70 deg. F, and in accordance with manufacturer's recommendations for application temperatures above or below 70 deg. F. Do not allow water or chemicals on the material surface for a minimum of 24 hours. For temperatures below 70 deg. F, cure a minimum of 72 hours prior to water or chemical exposure.

3.6 APPLICATION OF CHIMNEY SEALANT

A. The substrate surface prior to application of the sealant shall be clean and must be free of all foreign material and shall be completely dry. Abrasive blast or mechanically abrade metal surfaces in accordance with SSPC-SP 6 Commercial finish. All protrusions shall be ground smooth to eliminate sharp edges.

B. Sealant may be applied in a single application or pass by brush, trowel, or gloved hand in accordance with manufacturer's recommendations, to achieve a total minimum thickness of **1/4 inch (250 mils)**.

C. The sealant shall be applied from 6 inches above the bottom of the manhole frame and extend 6 inches below the manhole frame.

D. Allow a minimum of 24 hours for final cure before exposure to chemicals or water.

3.7 CLEANING

A. Clean interiors and remove all construction related materials, equipment and appurtenances from the structures prior to reinstatement of each service.

3.8 WEATHER

A. Cementitious Repair Materials: No application shall be made if ambient temperature is below 50 deg. F. No application shall be made to frozen surfaces or if freezing is expected to occur within the substrate within 24 hours after application. Precautions shall be taken to keep the mix temperatures at time of application below 90 deg. F. Mix water temperature shall not exceed 85 deg. F. Chill with ice if necessary.

B. Epoxy Liner Protective Coating: Maintain a temperature of 65 deg. F to 85 deg. F on air, substrate, and epoxy components during mixing, application, and cure. The monolithic components and substrate shall be maintained at 65 deg. F to 80 deg. F for 48 hours prior to beginning work.

3.9 PRODUCT TESTING

A. Four (4) - 2 inch cubes shall be cast each day or from every 50 bags of cementitious liner product used, and shall be properly packaged, labeled, and sent in for testing in accordance with the Owner's or manufacturer's directions, for compression strength testing as described in ASTM C109.

3.10 FINAL ACCEPTANCE TESTING

A. Upon completion of the rehabilitation work and after the appropriate curing time as recommended by the manufacturer, the Contractor shall perform a vacuum test on each rehabilitated manhole as detailed below. Each rehabilitated manhole shall be tested in the presence of the Engineer or Owner for field acceptance.

B. Vacuum Testing:

Manholes shall be tested in accordance with ASTM C1244-93, "Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum)

Test". Testing shall not be conducted earlier than seven (7) days after application.

1. Lift holes, if any, shall be plugged with an approved, non-shrinkable grout prior to testing.

2. The vacuum test shall include testing of the seal between the cast iron frame and the concrete cone, slab or grade rings.

3. The manholes shall be backfilled and finished to design grade.

4. Test Procedure:

   a. Temporarily plug, with the plugs being braced to prevent the plugs or pipes from being drawn into the manhole, all pipes entering the manhole at least eight inches into the sewer pipe(s). The plug must be inflated at a location past the manhole/pipe gasket.

   b. The test head shall be placed inside the frame at the top of the manhole and inflated, in accordance with the manufacturer's recommendations.

   c. A vacuum of 10" of mercury shall be drawn on the manhole. Shut the valve on the vacuum line to the manhole and disconnect the vacuum line.

   d. The pressure gauge shall be liquid filled, having a 3.5-inch diameter face with a reading from zero to thirty inches of mercury.

   e. The manhole shall be considered to pass the vacuum test if it holds at least 9 inches of mercury for the following time durations:

Minimum Test Times For Various Manhole Diameters

Depth (feet)	Time (sec) 4'-0" Dia.	5'-0" Dia.	6'-0" Dia.
8 or less	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121

Note: Where manhole depth falls between above values, round up to nearest depth value.

5. If a manhole fails the vacuum test, the manhole shall be repaired and re-tested, as stated above.

6. All temporary plugs and braces shall be removed after each test.

7. Manholes will be accepted as having passed the vacuum test requirements if they meet the criteria stated above.

C. A final visual inspection shall be made by the Engineer and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by the installer at no additional cost to the Owner.

D. High Voltage Holiday Testing:

After the epoxy liner protective coating has set hard to the touch (minimum 24 hour cure at a temperature of 70 deg. F) it shall be inspected with high-voltage holiday detection equipment. Surfaces shall first be dried, an induced holiday shall then be made on to the coated concrete surface and shall serve to determine the minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday (refer to NACE RPO188-99). All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional protective coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective coating manufacturer's recommendations.

E. A final visual inspection shall be made by the Engineer and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by the installer at no additional cost to the Owner.

3.11 WARRANTY

The manufacturer shall warrant that this product was produced in conformity with its standard specification for formulations within recognized tolerances, free of adulteration or contamination, and that the product will perform in accordance with manufacturer’s literature and technical data sheets when properly applied in strict conformance with the printed instructions on container and prescribed in technical data instructions and when applied to a properly prepared surface. The warranty shall be in force and effect for a period of three (3) years from the date of final acceptance by the Engineer.

END OF SECTION 02541

SECTION 02545
SANITARY FORCE MAINS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Sanitary force mains installed by the open trench method.
2. Low pressure sanitary sewers installed by the open trench method.
3. Products for sanitary force mains installed by horizontal directional drilling, boring and jacking, or pipe bursting methods.
4. Valves for pressure sewer mains, including air valves.

B. Related regulations include the following:

1. 327 IAC 3-6 Technical Standards of Sanitary Collection Systems

1.2 DEFINITIONS

A. HDD – Horizontal Directional Drilling

B. HDPE – high-density polyethylene plastic

C. Initial Backfill – backfill placed beside and over pipe in a trench

D. LPS – Low Pressure Sewer

E. PVC – polyvinyl chloride plastic

F. DI – ductile iron

G. CI – cast iron

1.3 SUBMITTALS

A. Prior to Installation, the Contractor shall provide the following information:

1. Product data for each type of product indicated.
    a. Pipe joints and fittings
    b. Tracer wire and warning tape
    c. Manhole castings
    d. Valves
    e. Precast concrete structures and accessories
2. Shop Drawings
    a. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
    b. Dimension and detail pipe and fitting layouts for all exposed pipe.
    c. Exposed pipe and fitting supports.

B. Project Record Documents – shall be provided in accordance with the Town's Record Drawing and Digital Data Submittal Requirements.

1.4 QUALITY ASSURANCE

A. Pipe, valves, and concrete valve vaults shall be new and free of defects and shall meet all applicable specification requirements.

B. Regulatory Requirements

1. Comply with standards of authorities having jurisdiction for sewer service pipe, including materials, installation, and testing.

2. Comply with requirements of IDEM and EPA regarding wastewater facilities and service.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic components, pipe, gaskets, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle pipe and structures according to manufacturer's written instructions.

D. Do not skid or roll products on or against other products.

E. Stacking of pipe shall meet the requirements of the pipe manufacturer.

F. Do not allow gaskets to come in contact with petroleum products.

1.6 PROJECT CONDITIONS

A. Do not interrupt sewer service or sewer flow unless permitted under the following conditions, and only after providing temporary sewer service:

1. Notify Engineer and Wastewater Superintendent no fewer than 2 days in advance of proposed service interruption.

2. Do not proceed with interruption of sewer service without Wastewater Superintendent's written permission.

3. Comply with requirements of Town Wastewater Department in providing temporary sewer service.

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipe and fitting sizes and all references to pipe diameter are intended to be nominal.

B. Special Applications and Material Limitations

1. Horizontal Directional Drilling

a. Shall be as described in Section 02410 – Horizontal Directional Drilling.

2.2 SANITARY FORCE MAINS

A. PVC Force Mains

1. PVC Pipe

a. Pipe and fittings shall be colored green for identification as wastewater pipe.

b. PVC pipe shall be used only in buried service.

c. Pipe sizes less than 4" shall conform to ASTM D2241, SDR 21.

d. Pipe sizes 4" and larger shall conform to AWWA C900, DR 18.

2. Pipe Joints

a. Open Trench or Boring and Jacking Installation

1) Joints shall be push-on flexible gasket compression-type conforming to ASTM F477.

2) Joints connecting to dissimilar pipe or fitting types shall be in accordance with manufacturer's recommendations.

3) Restraint devices shall have a working pressure equal to at least the pipe's working pressure.

4) No solvent cement joints shall be allowed.

3. Fittings and fitting joints shall be DI meeting the requirements of AWWA C110, standard pattern or AWWA C153, compact pattern.

a. Mechanical joints in accordance with AWWA C110 and AWWA C111.

b. Push-on type joint conforming to AWWA C111.

c. Manufactured restrained joints under conditions indicated by manufacturer.

d. Restraint devices shall have a working pressure equal to at least the pipe's working pressure rating.

B. Ductile Iron Force Mains

1. Ductile Iron Force Main Piping shall meet the requirements of specification 11310, Item 2.13.

2. Encasement – for buried service

a. Polyethylene encasement shall conform to AWWA C105.

b. Shall be green in color.

C. HDPE Force Mains

1. HDPE Pipe

a. HDPE pipe resin shall meet ASTM D3350.

b. Pipe dimensions and manufacturing shall be per ASTM 3035 or ASTM F714.

c. Pipe shall be SDR 11 for all pipe sizes and pressure class shall be Class 200.

d. HDPE shall be used only in buried service. Pipe shall be green-striped or green in color.

2. Joints

   a. Fusion butt-welded.

3. Fittings

   a. Manufactured in accordance with standard design pressure classes, dimensions, and temperature ranges specified for HDPE pipe.

   b. Fittings shall be fusion welded or electrofusion type.

   c. Do not use tapping sleeves for main-to-main connections.

   d. Fittings shall not be field fabricated.

   e. Stiffeners shall be provided by fitting manufacturer and acceptable to pipe manufacturer.

   f. Connections to other pipe types shall use a "Harvey" type mechanical joint adapter.

D. Restrained Joints (For Open Cut Installation)

1. PVC and Ductile iron pipe and fittings shall be as specified in Parts 2.01 and 2.02 of these specifications, respectively, and include restraints systems as specified below.

2. Restrained joints for pipe, fittings, and valves shall be required where shown on the Drawings, and applies to restrained joints at ductile iron fittings, across the joints of bell and spigot pipe joint, and where the spigot end of pipe connect with valves or other items that have mechanical joints ends. Mechanically restrained joints sanitary force mains shall be as follow:

   a. Ductile Iron Pipe: Pipe restraint shall be accomplished by mechanical joint retainer glands cast of ductile iron ASTM A536, Grade 65-42-12, and equipped with special cupped and set screws. Restraining devices shall be Mega-Lug Series 1100, 1100SD, 1100HD, and 1700 (as applicable) as manufactured by EBAA Iron Sales, Inc. Eastland, Texas; or equal.

      Alternatively, in lieu of mechanical joint retainer glands, restrained push-on ductile iron pipe may be used including FLEX-RING Restrained Joint by American Ductile Iron Pipe; TR FLEX Restrained Joint by U.S. Pipe; or equal, meeting the same requirements as specified in Paragraph 2.02 as applicable.

   b. PVC Pipe: Pipe restraint shall be accomplished by mechanical joint retainer glands cast of ductile iron ASTM A536, Grade 65-45-12, and equipped with special cupped and set screws. Restraining devices shall be Mega-Lug Series 1600, 2000PV, 2000SV or 2800 (as applicable) as manufactured by EBAA Iron Sales, Inc., Eastland, Texas; or equal.

   c. Restrained joints shall have a minimum working pressure equal to that of the pipe, with a minimum 2:1 safety factor.

   d. All bolts, nuts, and studs for mechanical joint restraint devices shall be fluoropolymer coated steel or 300 Series stainless steel. After field

installation, all steel (not stainless) surfaces shall have one (1) coat of Sherwin-Williams Targuard; or equal, coal tar epoxy coating applied before backfill.

e. To ensure uniformity of installation and appearance, all restraint devices shall be the products of one manufacturer.

2.3 WARNING TAPE

A. General

1. Warning tape shall be made of inert materials, resistant to alkalis, acids, and other destructive agents found in soil.
2. Warning tape shall have a minimum thickness of 4 mils.
3. Warning tape width shall be a minimum of 3" and a maximum of 6".
4. Imprint shall repeat a minimum of once every 2 feet of tape length.
5. Warning tape shall be aluminum-backed or have a foil core detectable by a cable locator.

B. Material

1. Warning tape shall be imprinted with "CAUTION – SANITARY SEWER BURIED BELOW" or similar wording.
2. Tape shall be green in color or green striped with black printed lettering.

C. Warning tape shall be Terra Tape Sentry Line by Reef Industries, Inc., or approved equal.

2.4 TRACER WIRE

A. Tracer wire shall be copper-clad high carbon steel or solid copper.

B. Insulation shall be HDPE complying with ASTM D1248, 30-volt rating and shall be green in color.

C. Composite conductivity shall be 21% IACS (International Annealed Copper Standard).

D. Minimum physical characteristics:

1. AWG: 10
2. Insulation thickness: 0.030"
3. Breaking load: 1,000 lb

E. Connectors shall be from manufacturer's packaged kit, consisting of insulating spring-type connector or crimped joint and epoxy resin moisture seal, suitable for burial.

2.5 TRACER WIRE BOXES

A. General

1. Cylindrical construction with removal round lid.
2. Support flange at the base at least 1/2" wide.
   a. If box is designed for use with integral valve support, flange may be omitted.

3. Telescoping design with upper and lower tubes overlapping 3” when the box is extended to its maximum length.

4. Magnetized to amplify tracer signal.

a. A magnet shall be securely attached on the upper inside of the box or encapsulated within the lid.

B. Material

1. Box material shall be high grade ABS or equivalent rigid plastic that meets ASTM D1788, Type 1.

2. Lid material shall be cast iron or ductile iron, with tensile strength or ductility meeting ASTM A126-B.

C. Box Lid

1. Colored green for wastewater per APWA standards.

2. Lock with a tamper-resistant pentagon locking nut.

3. Internal corrosion-resistant brass wire lug for tracer wire connection, and a wax pad to block out moisture at the wire connection.

D. Tracer wire boxes shall be Snakepit Lite Duty Access Point by Copperhead Industries in unpaved areas, Snakepit Roadway Access Point by Copperhead Industries in paved areas, or approved equal.

2.6 PLUG VALVES

A. Shall meet the requirements of specification 11310 Item 2.15.

2.7 AIR VALVES

A. Air Release Valves and Combination Air Valves

1. Connections

a. Valves shall have full size NPT inlets equal to nominal valve size.

b. All valves shall have additional NPT connections for backwash accessories, gauges, testing, and draining.

c. Valves shall be connected to force main as shown in the Town’s standard detail.

d. Full flow stainless steel ball-type shut-off valve of same size as valve inlet shall be provided.

2. Body and Seat

a. Valve body shall be corrosion resistant reinforced nylon or stainless-steel construction.

b. Valve seat shall provide drop tight shut-off to the full pressure rating.

3. Backwash accessories, including shut-off valve, quick-connect couplings, and flexible extension hose, shall be provided by manufacturer.

4. Valve shall have a corrosion resistant operating mechanism allowing the valve to fully open under full operating pressure.

5. Valve shall be rated for a maximum working pressure of at least 150 psi.

6. Wastewater combination air valves shall be the following as manufactured by ARI, or approved equal:

   a. ARV diameter size of 2” and ARV Model D-025, D-025L, or approved equal for force mains with diameter 3” to 8”.

   b. ARV diameter size of 3” and ARV Model D-025, D-025L, or approved equal for force mains with diameter 10” to 16”.

B. Air Valve Vaults

1. Precast reinforced-concrete vault designed according to ASTM C478. The vault shall be rated for H20 traffic loading if located in a pavement area.

2. Frame and cover shall be 1022 by East Jordan Iron Works, or approved equal.

2.8 HDPE TAPPING SADDLES

A. Service saddles shall be HDPE PE 4710 electrofusion type rated for 200 psi. Any metal components shall be stainless steel.

2.9 HDPE BALL VALVES

A. HDPE Ball valves shall be made of PE4710 resin with cell classification 445574C in accordance with ASTM D3350.

B. The valve shall be suitable for use up to 200 psi.

C. The valve operation shall be ¼ turn clockwise open using a 2” square nut.

D. The valve shall be compatible for heat fusion with similar HDPE pipe and materials.

E. Valve shall be marked with the following information:

1. Nominal Pipe Size

2. Type Plastic Material – PE4710

3. Pipe Pressure Rating

4. Manufacturer’s Name, Trademark and Code

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Connect force mains per Town standards.

1. HDPE Pipe Connections

   a. Provide longitudinal restraint designed to withstand thermal expansion and contraction of pipe at all connections to structures and pipe of dissimilar materials. Harvey Adapters to be used for all Mechanical Joint connections.

   b. Use stiffeners approved by pipe manufacturer for at all mechanical connections except flange adapters.

      1) Install flange adapters according to pipe and adapter manufacturer’s recommendations.

B. Install ductile iron pipe and fittings according to AWWA C600 and AWWA M41.

1. Install PE corrosion-protection encasement according to ASTM A674 or AWWA C105.

C. Install PE pipe and fittings according to the following:

1. ASTM D2774 and ASTM F645.

2. Handbook of Polyethylene Pipe.

3. AWWA M55.

D. Install PVC pipe and fittings according to ASTM F645 and AWWA M23.

E. Sanitary force mains shall be laid at least 10 feet horizontally from any existing or proposed water main, measured edge to edge. Notify Engineer if this separation cannot be met.

F. Sanitary force mains crossing water mains shall be laid so that 18" of vertical clear space remain between the force main and water main. Notify Engineer if this separation cannot be met.

3.2 JOINT CONSTRUCTION

A. Make pipe joints according to the following:

1. Ductile Iron Pipe Gasketed Joints: AWWA C600 and AWWA M41.

2. PE Pipe: ASTM D2774 and ASTM F645.

3. PVC Pipe Gasketed Joints: Use materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D2774 or ASTM D3139 and pipe manufacturer's written instructions.

4. Dissimilar Materials Pipe Joints: Use adapters compatible with both pipe materials, with OD, and with system working pressure.

3.3 ANCHORAGE INSTALLATION

A. General

1. Install underground pipe with restrained joints at horizontal and vertical changes in direction.

2. Install anchorages for tees, plugs and caps, bends, crosses, and valves.

3. Anchorages and restrained-joint types that may be used include:

a. PVC Pipe

1) Field-adaptable restraint systems.

b. DI Pipe

1) Locking mechanical joints.

2) Bolted flanged joints.

3) Field-adaptable restraint systems.

c. HDPE

1) Heat-fused joints.

B. Include anchorages for the following pipe systems:

1. Gasketed-Joint, Ductile Iron Force Main Pipe: per AWWA C600.

2. Gasketed-Joint, PVC Force Main Pipe: per AWWA M23.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices. All bolts shall be either stainless steel or fluoropolymer coated.

3.4 VALVE INSTALLATION

A. Plug valves shall comply with AWWA C600 and AWWA M44. Install each plug valve with stem pointing up. Install valve box for all buried applications.

3.5 AIR VALVE INSTALLATION

A. Install in a vertical position with the inlet facing downwards.

B. Install at all high points where indicated with exact location determined at time of construction.

C. Maintain a continuous positive grade of the pipe to the air valve location and a continuous negative grade of the pipe away from the air valve to avoid high spots in the lines between the valves.

1. Pipe shall be installed to a grade necessitating only the number of valves indicated.

D. No air valves and vaults shall be placed in areas subject to vehicular traffic without prior written approval of Engineer and Wastewater Superintendent.

E. Depth of force main shall be adjusted downwards as necessary to provide adequate clearance between top of valve vault with top of valve and fittings.

F. A stainless-steel valve shall be provided between the force main and air valve.

G. The valve shall be supported with stainless steel brackets attached to the concrete vault structure.

3.6 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C891.

B. Elevation of valve vault and grading around the vault shall provide for positive runoff away from the vault.

3.7 FLUSHING CONNECTIONS

A. Install every 400 feet and at dead ends on LPS mains, and where two LPS mains come together.

3.8 INSTALLATION OF WARNING TAPE

A. Warning tape shall be installed over all buried non-metallic pipe in accordance with manufacturer's installation instructions.

B. Warning tape shall be installed 12" above the pipe centerline unless noted otherwise on plans.

3.9 INSTALLATION OF TRACER WIRE

A. Provide two tracer wires on the crown of all pipes and tubing.

B. Wires shall be installed along the pipe and securely fastened by two full wraps of duct tape at no more than 20 foot intervals.

C. Terminate tracer wires above ground at each at-grade or above-ground structure and at intervals of no more than 400 feet.

1. Bring tracer wires to grade through a tracer wire box where no structures exist.

2. Do not terminate tracer wires within limits of waterways.

D. Individually test each tracer wire strand after installation. At least one of the two tracer wires shall provide continuous transmission of tracing signal along the full pipe length.

3.10 PAINTING

A. See specification 11310 Item 2.13 for field painting requirements of exposed piping.

3.11 FIELD QUALITY CONTROL

A. Hydrostatic Tests

1. Provide all equipment for testing and conduct tests in presence of Engineer.

2. Test all new force mains, valves, and air valves.

a. Test pressure shall be at least 1.5 times the working pressure at the point of testing, or 50 psig, whichever is greater.

b. Test each valved section separately.

c. Install necessary test ports and blow-offs using service saddles and corporation stops.

d. Prior to tests, slowly fill pipe with potable water, then flush to expel air.

3. Fill pipeline with potable water and apply test pressure 24 hours before testing.

4. Conduct hydrostatic tests for 2 hours to 6 hours.

5. Follow AWWA C600 for DI pipe and AWWA C605 for PVC pipe.

6. Do not exceed pipe and/or thrust resistant design pressures during test.

7. Do not vary pressure by more than ± 5 psi for the duration of the test.

B. Pressure Test

1. Apply pressure with a hydrostatic test pump designed specifically for the purpose. Pump system shall include accurate pressure gauge measuring outlet pressure.

2. Examine exposed pipe, fittings, valves, and joints during the test.

3. Correct visible leaks or defects discovered during the pressure test. Repeat the test until no defects are identified.

4. At the conclusion of the pressure test, cap the corporation stop outlets.

C. Leakage Test

1. After the completion of the pressure test, conduct a leakage test 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.

2. Leakage shall not be measured by a drop in pressure over time.

3. No ductile iron pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = (S * D * \sqrt{P}) / 133{,}200$$

Where:

L = allowable leakage, in gallons per hour

S = length of pipe tested, in feet

D = nominal diameter of the pipe, in inches

P = average test pressure during the leakage test, in psi

4. No PVC pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = (N * D * \sqrt{P}) / 7{,}400$$

Where:

L = allowable leakage, in gallons per hour

N = number of joints in length tested

D = nominal diameter of the pipe, in inches

P = average test pressure during the leakage test, in psi

5. Acceptance

   a. Acceptance shall be determined based on allowable leakage. If any test indicates leakage greater than that specified, the Contractor shall at his own expense, locate and make approved repairs as necessary until the leakage is within the specified allowance.

   b. All visible leaks are to be repaired regardless of calculated leakage.

   c. If a tested section contains sections of various diameters, allowable leakage will be the sum of the computed leakage for each size.

D. Prepare and submit reports of testing activities to Engineer.

END OF SECTION 02545

SECTION 11310
SUBMERSIBLE PUMP LIFT STATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes submersible pump lift station structures and equipment, including:
   1. Wet wells and valve vaults.
   2. Pumps.
   3. Guide rails and pump removal components.
   4. Pipe and Valves.
   5. Pump control and Alarm system.
   6. Electrical Equipment
   7. Other Accessories and Appurtenances to the Lift Station

B. Other Lift Station Components Specified Elsewhere:
   1. Emergency Generator
   2. Automatic Transfer Switches
   3. Site Improvements – See Lift Station Standard Drawings as well as the Town Design and Construction Standards

1.2 DEFINITIONS

A. NEC – National Electric Code
B. ANSI - American National Standards Institute.
C. ASTM - American Society for Testing & Materials.
D. HI - Hydraulic Institute.
E. NEMA - National Electric Manufacturer's Association
F. NFPA – National Fire Protection Association
G. UL – Underwriters Laboratories

1.3 SUBMITTALS

A. The submittal items listed below shall be provided to the Town by the installing contractor as a part of the lift station construction.
B. Product Data:
   1. Control and Alarm system products.
   2. Pump and motor data

3. Guide rails and pump removal system components.
4. Valves and Pipe Materials.
5. Other manufactured components.

C. Shop Drawings
1. Wet well and valve vault construction, including:
a. Dimensioned drawings of precast concrete components, including details of reinforcing steel.
b. Calculations indicating compliance with standards and specifications, sealed by an engineer registered in the location of the project.
2. Dimensioned pipe, structure, and valve layouts.
3. Electrical control panels.

D. Manufacturer Test Reports
1. Manufacturer's factory test results on pumps.
2. UL certification for control panel.
3. Test reports of compressive strength test on precast concrete components.
4. Schedule of Tests and Inspections
5. Manufacturer's instructions.
6. Product warranties.

1.4 QUALITY ASSURANCE

A. Pumps shall be manufactured and tested in accordance with the applicable requirements of the Hydraulic Institute and ASTM/ANSI standards.

B. All pump and control equipment shall be as an integral package supplied by a single supplier.

C. Pump manufacturer shall have a local certified repair company capable of providing on-site emergency service within 24-hours of notice.

D. Electrical shall meet all applicable requirements of the National Electrical Code and state and local regulations.

E. Comply with requirements of IDEM regarding wastewater facilities and service.

1.5 WARRANTY

A. Pump manufacturer shall warrant the pumps being supplied against defects in workmanship and materials for a period of 5 years under normal use, operation, and service. Manufacturer shall replace parts which shall become defective through normal use and wear on a progressive schedule of cost for a period of 5 years, including mechanical seal, impeller, pump housing, wear ring, and ball bearings. Warranty shall not start until the equipment has been placed in operation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall be responsible for the delivery, storage, and handling of products.

B. Load and unload all pumps, motors, and appurtenances by hoists or skidding. Do not drop products. Do not skid or roll products on or against other products. Pad slings and hooks in such a manner to prevent damage to products.

C. The pumps furnished shall be packaged in such a manner as to provide ample protection from damage during handling, shipment, and outdoor storage at the lift station site. All openings shall be capped with dustproof closures and all edges sealed or taped to provide a dust-tight closure.

D. Promptly remove damaged products from the job site. Replace damaged products with undamaged products.

1.7 SCHEDULING

A. Ensure completion and acceptance of upstream and downstream facilities prior to testing and commissioning.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish a complete lift station consisting of submersible non-clog sewage pumps, pipe, valves, concrete wet well, electrical controls, guide system, and other appurtenances as specified in this section and as shown on the drawings.

2.2 ACCEPTABLE PUMPING SYSTEMS

A. Pumps shall be Flygt or approved equal.

2.3 SUBMERSIBLE PUMPS

A. Pump Design

1. The pump shall be of the submersible type capable of handling raw, unscreened wastewater and 3” diameter spherical solids.
2. The pump, with its motor, power cable and all appurtenances, shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 ft.
3. The pump shall be able to be installed and removed without the need for personnel to enter into the wet well.

B. Pump Construction:

Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts or bolts shall be of stainless steel construction. All metal surfaces coming into contact with the pumpage, other than stain-

less steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.

Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.

C. Cooling System:

Motors are sufficiently cooled by surrounding environment or pumped media. A water jacket is not required.

D. Cable Entry Seal:

The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of single (cylindrical elastomer grommet(s), flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter. The grommets shall be compressed by the cable entry unit, thus providing a strain relief function. The assembly shall provide ease of changing the cable when necessary using the same entry seal. The cable entry junction chamber and motor shall be sealed from each other, which shall isolate the stator housing from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

E. Motor:

The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake-type stator insulation process is not acceptable. The use of pins, bolts, screws or other fastening devices used to locate or hold the stator and that penetrate the stator housing are not acceptable. The motor shall be designed for continuous duty while handling pumped media of up to 104°F. The motor shall be capable of withstanding at least 15 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of aluminum. Three thermal switches shall be embedded in the stator end coils, one per phase winding, to monitor the stator temperature. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the motor control panel.

The junction chamber shall be sealed off from the stator housing and shall contain a terminal board for connection of power and pilot sensor cables using threaded compression type terminals. The use of wire nuts or crimp-type connectors is not acceptable. The motor and the pump shall be produced by the same manufacturer.

Motors shall be _____V, 60 Hz, __ phase. The motor service factor (combined effect of voltage, frequency and specific gravity) shall be 1.15. The motor shall have a voltage tolerance of +/- 10%. The motor shall be designed for continuous operation in up to a 40°C ambient and shall have a NEMA Class B maximum operating temperature rise of 80° C. A motor performance chart shall be provided upon request exhibiting curves for motor torque, current, power factor, input/output kW and efficiency. The chart shall also include data on motor starting and no-load characteristics.

The power cable shall be sized according to the NEC and ICEA standards and shall be of sufficient length of reach the junction box without the need of any splices. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet.

The motor horsepower shall be sufficient so that the pump is non-overloading throughout its entire pump performance curve, from shut-off through run-out. **The pump/motor/cable assembly shall be suitable for use in NEC Class I, Division 1, Groups C and D hazardous locations.**

F. Bearings:

The pump shaft shall rotate on two bearings. The motor bearings shall be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing shall be a single deep groove ball bearing. The lower bearing shall be a two row angular contact ball bearing to compensate for axial thrust and radial forces. The minimum L_{10} bearing life shall be 50,000 hours at any usable portion of the pump curve.

G. Mechanical Seals:

Each pump shall be provided with a positively driven dual, tandem mechanical shaft seal system consisting of two seal sets, each having an independent spring. The lower primary seal, located between the pump and seal chamber, shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide ring. The upper secondary seal, located between the seal chamber and the seal inspection chamber, shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide seal ring. All seal rings shall be individual solid sintered rings. Each seal interface shall be held in place by its own spring system. The seals shall not depend upon direction of rotation for sealing. Mounting of the lower seal on the impeller hub is not acceptable. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces are not acceptable. The seal springs shall be isolated from the pumped media to prevent materials from packing around them, limiting their performance.

Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and shall provide capacity for lubricant expansion. The seal lubricant chamber shall have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system shall not rely upon the pumped media for lubrication.

The area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

A separate seal leakage chamber shall be provided so that any leakage that may occur past the upper, secondary mechanical seal will be captured prior to entry into the motor stator housing. Such seal leakage shall not contaminate the motor lower bearing. The leakage chamber shall be equipped with a float type switch that will signal if the chamber should reach 50% capacity.

H. Pump Shaft:

The pump and motor shaft shall be a single piece unit. The pump shaft is an extension of the motor shaft. Shafts using mechanical couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T. Shaft sleeves will not be acceptable.

I. Impeller:

The impeller shall be of "Hard-Iron" (ASTM A-532, Alloy III A, 25% chrome cast iron), dynamically balanced, semi-open, multi-vane, back swept, screw-shaped, non-clog design. The impeller leading edges shall be mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction. The leading edges of the impeller shall be hardened to Rc 60 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter normally found in wastewater. The screw shape of the impeller inlet shall provide an inducing effect for the handling of up to 5% sludge and rag-laden wastewater. The impeller to volute clearance shall be readily adjustable by the means of a single trim screw. The impeller shall be locked to the shaft, held by an impeller bolt and shall be coated with alkyd resin primer

J. Volute/Suction Cover:

The pump volute shall be a single piece gray cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified. The volute shall have integral spiral-shaped, sharp-edged groove(s) that is cast into the suction cover. The spiral groove(s) shall provide the sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed. The insert ring shall be cast of ASTM A-532 (Alloy III A) 25% chrome cast iron and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

K. Protection:

Each pump motor stator shall incorporate three (3) thermal switches, one per stator phase winding and be connected in series, to monitor the temperature of the motor. Should the thermal switches open, the motor shall stop and activate an alarm. A float switch shall be installed in the seal leakage chamber and will activate if leakage into the chamber reaches 50% chamber capacity, signaling the need to schedule an inspection. When activated, the float switch will stop the motor and send an alarm both local and/or remote.

The thermal switches and float switch contacts shall be connected to a Flygt "Mini CAS II" control and status monitoring unit mounted in the pump control panel.

L. Nameplates

1. Each piece of mechanical equipment shall be provided with a substantial nameplate, securely fastened in place and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data.
2. A second identical nameplate shall be provided for all submersible pumps and affixed to the interior of the control panel.

2.4 PUMP REMOVAL SYSTEM

A. The guide rail system for pump removal shall be provided by the pump manufacturer for the pump model provided.

B. A sliding guide bracket shall be an integral part of the pump unit. The volute casing shall have a machined discharge flange to automatically and firmly connect with the cast iron discharge connection which, when bolted to the floor of the sump and discharge line, will receive the pump discharge, connecting without the need of adjustment, fasteners, clamps, or similar devices.

C. Installation of a pump unit to the discharge connection shall be the result of a simple linear downward motion of the pump unit guided by two guide rails or other suitable guide system. No other motion of the pump unit, such as tilting or rotating, shall be required.

D. Guide rail pipes shall be constructed using 304 stainless steel. Systems deeper than 12 feet shall use an intermediate guide at maximum 10 ft intervals.

E. No portion of the pump unit shall bear directly on the floor or wet well. There shall be no more than one 90 degree bend allowed between the volute discharge flange and station piping.

F. Lifting System

1. A 12” length of 9/32” stainless steel lifting chain shall be supplied for removing each pump. The chain shall be attached to the pump per the manufacturer’s recommendations. The chain shall provide at least 4:1 safety factor in strength.
2. The chain shall be connected a nylon rope which shall be connected near the access hatch above the pumps to allow easy accessibility. Rope shall be 3/16” diameter smooth braid type, with a minimum weight capacity of 80 lbs.

2.5 LEVEL CONTROL SENSORS

A. Submersible Pressure Transducer

1. Pumps shall be controlled by a submersible pressure transducer.
2. Isolated diaphragm sensor design specifically manufactured for use in hostile fluids and gasses.
3. Silicon pressure cell sensor with integral, compliant stainless steel barrier diaphragm.
4. Sensor assembly case shall be rugged 316 SS with variety of pressure inputs as well as electrical output connections.
5. Static accuracy of +/- 1% FSO BFSL.

6. Certified intrinsically safe for hazardous locations.
7. Datalogger compatible.
8. Fully temperature compensated.
9. Waterproof connection cable shall be of sufficient length to reach the terminal blocks in the junction box on the top of the wet well.
10. Acceptable Manufacturers: Amertek (model 575), Danfoss Inc. (Danfoss Preslev)

B. Float Switches

1. Backup control of pump on, off, lag, and alarm levels shall be by float switches.
2. Switches shall consist of a mercury tube switch sealed in a corrosion-resistant polypropylene housing with minimum 18 gauge, 2 wire, SJOW/A jacketed cable.
3. Float switches shall be connected to a manifold and suspended from a stainless steel bracket so that adjustment or replacement may be done without the use of any tools.
4. The manifold shall have a waterproof cable connection of sufficient length to reach the terminal blocks in the junction box on top of the wet well.
5. The manifold connection system shall be the SJE Rhombus EZconnex 4-port float system or equal.

2.6 PUMP CONTROL PANEL

A. Control panel enclosure shall be NEMA 4X Type 304 stainless steel, with a minimum thickness of 14 gauge. Double walls are not acceptable.

B. All penetrations through compartments shall be performed to maintain the NEMA ratings of each individual compartment.

C. All conduit entries into the enclosure from the wet well shall be sealed to prevent moisture and vapors from entering the enclosure.

D. Exterior door handles shall be die-cast aluminum alloy. Door handles shall be fully lockable and NEMA rated to maintain the rating of the associated compartment. Door hinges shall be continuous Type 304L stainless steel piano type hinges.

E. Mechanical door stops shall be provided on the exterior door of the enclosure to secure the door(s) in the open position.

F. A thermoplastic data pocket is to be mounted on the door of the enclosure.

G. A drip cap shall be installed as one continuous sheet of stainless steel covering the entire top of the enclosure. The drip cap shall be minimum 14 gauge stainless steel.

H. The control panel shall have a dead front inner door constructed of 1/8” aluminum with a piano type hinge to mount controller, indicator, and switches.

I. The interior of the enclosure shall be provided with properly sized corrosion inhibitors.

J. The back panel shall be a minimum of 1/8" aluminum mounted to the enclosure by 3/8” studs and nuts.

K. A thermostat and heater shall be provided for each exterior control panel to prevent condensation and freezing.

L. A surge suppressor shall be provided in the control panel to protect all connected electrical equipment.

M. Panel shall include override relay, terminal blocks, 2 ground lugs, and all necessary wiring and brackets.

N. All internal wiring shall be neat and color coded. Each wire shall be a different color or stripe (except for ground), and all incoming wires shall terminate into a box clamp type terminal block (except incoming power). A schematic diagram showing wire color shall be permanently fastened to the inside of the enclosure.

O. Circuit breakers shall be provided for each pump and for the control circuit.

P. A control transformer with primary fusing shall be provided for the control circuits where 120V power supply is not available.

Q. For all control panels provided 3-phase power, socket-type power phase monitor shall shut down the control circuit and protect the 3-phase equipment upon loss of phase, phase imbalance, or phase reversal.

R. A weatherproof flashing alarm light with a red bulb shall be mounted on the outside of exterior control panels. A weatherproof audible alarm horn shall be mounted on the outside of exterior control panels. Horn shall be rated at 103 dB minimum.

S. A 20A 120V GFI convenience outlet shall be located on the inside of the control panel.

T. A mounting package shall be furnished to mount the control panel. All necessary hardware to mount the control panel shall be stainless steel.

U. The Panel shall include an interior LED light to illuminate the interior for maintenance. A switch for the light(s) shall be provided.

V. The Panel shall include a circuit and switch for the control of a pole mounted light on the lift station site. See item 2.18 in this specification for light requirements.

2.7 PUMP CONTROLS

A. The pump controls shall be mounted on an internal panel face of the control panel and be capable of controlling the pumping system.

B. Pump Controls

1. HOA Switches - Each pump shall be controlled by a hand-off-auto switch.

2. Digital Pump Controller

a. Stations utilizing VFD's: The controller shall be Energy View by Primex or approved equal.

b. Stations utilizing motor starters: The controller shall be Level View by Primex or approved equal.

c. Digital readout and a keypad for entering operational settings.

d. Capable of accepting a pressure input of 0 to 35 feet, a current input of 4 to 20mA, or a voltage input of 0 to 10 volt (field selectable) that will function with any type of level transmitter.

e. Control adjustments shall be accomplished by direct digital inputs (potentiometers or other analog adjustments shall not be acceptable).

f. Allows for programming changes and complete level simulation from the front of the control plate without codes or special keypad sequences.

g. LED indicators shall be lighted and identify the function to be changed as the operator steps through the programming mode.

h. One 4 to 20 mA analog output.

i. Digital outputs from the controller shall be normally open relay contacts rated for 120 vac.

j. One RS485 serial port capable of operating with standard Modbus protocols.

3. Backup Float Pump Controller

a. An SJE model DPC-4F controller shall be provided as a backup float pump controller.

C. Pump Control Sequence

1. Lead pump shall be started in Auto mode by the "On" level sensor.

2. Lag pump shall be started in the "Auto" mode by the "Lag" level sensor.

3. Alarm light shall be activated by "Alarm" level sensor.

4. All pumps shall be turned off by the "Off" level sensor. Pumps may continue to be operated in "Hand" position with the level below the "Off" level sensor.

D. Control Lights and Switches

1. Control lights on the inside panel shall be provided for the following conditions:

a. Pump run (green) for each pump.

b. Moisture in pump (amber) for each pump.

c. Power on (red) for control panel.

2. Switches or buttons will be provided on the inside panel for:

a. alarm test (pushbutton).

b. alarm reset (pushbutton).

c. test lights (pushbutton).

3. No control lights shall be provided on the panel exterior.

E. Motor Starters

1. Combination Starters – For pumps less than 25 HP, unless indicated otherwise, provide IEC rated Full Voltage Non Reversing (FVNR) starters.

2. Soft-Start Starters – Where otherwise indicated and for pumps over 25 HP, provide Reduced Voltage Solid State (RVSS) starters. Starters shall be equipped with isolation and bypass contactors. IEC rated contactors are allowed.

3. Variable Frequency Drives – Where specified, on a case by case basis, shall be Danfoss VLT Aqua and sized for the pump horsepower to be provided.

F. Alarm Telemetry Unit

1. Shall be Pump Watch by Primex or approved equal.

2. Alarm Conditions.
    a. Low Level
    b. High Level
    c. Pump 1 Seal Fail
    d. Pump 1 Overload Trip & Over Temperature
    e. Pump 2 Seal Fail
    f. Pump 2 Overload Trip & Over temperature
    g. Power Failure.
3. Provide cellular telephone service to telemetry unit. Coordinate account and programming with Wastewater Superintendent.

G. A solid state alternator relay shall be provided to automatically alternate pumps between lead and lag operation after each run.

H. Provide motor winding heat sensor circuit from each pump equipped with heat sensor. Circuit shall disconnect the starter upon high temperature signal and automatically reset when condition is corrected.

I. Provide seal failure alarm circuit from each pump equipped with seal failure sensor. Seal failure alarm shall energize panel alarm light but not disconnect the starter.

J. Time-Delay Relays:
1. Relays shall be of the plug-in socket design.
2. Operate on 24 or 120VAC, as applicable for the controls design, and shall have DPDT contacts rated at 10A minimum.
3. Have a red LED for output contact status.
4. Be on-delay or off-delay as required.
5. Delay the start of the lag pump upon restoration of power after outage.

K. Nameplates and Identification
1. Provide screw-in type, engraved nameplates or laser-screened laminated mylar identification labels for all controls, disconnects, indicators, and lights on outer or inner panel doors.
2. Provide laser-screened laminated mylar identification labels for major components inside panel such as circuit breakers, motor starters, and transformers
3. Provide permanent printed labels or legible permanent marker identification for relays, fuses, phase monitors, surge arrestors, and any other minor equipment within panel.
4. All control wiring shall be numbered on each termination.

L. Surge Protection
1. Provide Category C-1 surge suppressor where the largest downstream motor is 10 horsepower or less, Category C-2 for motors to 25 HP, and C-3 for motors are larger than 25 HP.
2. Surge suppressor shall be designed for use at service entrance.

M. Acceptable Manufacturers:

1. Motor starters and control components: Allen Bradley, Danfoss Inc.
2. Circuit breakers and motor circuit protectors: Square “D”
3. Beacon light: Federal Signal (Fireball 2)
4. Alternator: Furnas

2.8 ELECTRICAL EQUIPMENT

A. All electrical device enclosures shall be NEMA 4X Stainless Steel

1. All conduit shall be SCH 80 PVC with the exception of the conduits between the wet well junction box and control panel which shall be PVC coated aluminum.
2. See Sanitary Lift Station Electrical Details (LS-2) for additional requirements.

2.9 ELECTRIC POWER SUPPLY AND DISTRIBUTION

A. Provide underground electric power supply to electric meter according to directions of electric company.

B. Provide mounting panels for power supply and control panels as shown on drawings.

C. Provide disconnects, grounds, conduit, fuse and breaker boxes, wiring, and other electrical power distribution components as provided in the contract documents and as required by electrical codes.

2.10 STRAIN RELIEF GRIPS

A. All pump power and sensor cables shall be fitted with stainless steel Kellems type strain relief grips.

B. Cable restraints shall support the cables from the top of the wet well.

C. Strain relief grips shall be attached by stainless steel hooks with snap clips.

2.11 PRECAST CONCRETE WET WELL AND VALVE VAULT

A. Contractor shall furnish and install precast concrete wet well as indicated on the drawings. Pumps and related equipment shall be installed or mounted as shown.

B. A precast concrete valve vault shall be furnished and installed to house the valves and appurtenances.

C. All bases, barrels, and tops for wet wells and valve vaults shall be precast reinforced concrete capable of withstanding external pressures including live surface loads, soil pressures and groundwater buoyancy to the finished grade in combination with internal pressures due to variable liquid elevations from empty to the top of the structure.

D. Materials

1. All precast concrete structures shall be watertight and of durable materials not subject to decay or excessive corrosion.
2. Minimum compressive strength for all concrete shall be 4,000 psi at 28 days.
3. Reinforcing steel shall meet ASTM A615 with a yield strength of 60,000 psi.
4. Design and Manufacture of precast reinforced sections shall conform to ASTM C478 (round structures) or ASTM C913 (square structures). Handling or lifting lugs shall be provided for ease of unloading and placement.
5. Joints shall have tongue and groove O-ring seals and/or butyl joint sealants meeting requirements of ASTM C443 and/or ASTM C990.
6. External joint wraps shall comply with ASTM C877 by Cretex Specialty Products, or approved equal.
7. Pipe connections through all precast concrete walls for ductile iron pipe shall be modular seals designed for precast concrete structure pipe penetrations, similar to Link-Seal Model S-316.
8. The exterior of all wet wells and valve vaults shall be coated with a spray-on asphaltic seal coat.

2.12 ALUMINUM ACCESS HATCHES

A. Access hatches shall be single or double leaf opening of the sizes (opening dimensions) as shown on the Drawings. The hatches shall be factory assembled and precast into concrete top slabs at the factory where applicable. The hatches shall be furnished with Type 316 stainless steel hinges and pins, stainless steel hold open positive locking arm with spring assist & release handle, flush lift handles, stainless steel slam-lock with removable key, padlock locking bar, and odor resistant gasket. Hatch door shall open 90 degrees and close flush with the frame and concrete slab.

B. Door leafs shall be fabricated from ¼" thick 5086-H34 mill finish aluminum diamond pattern plate, reinforced with ¼" aluminum flat bar(s). Covers shall be reinforced to be capable of withstanding a uniform live load of 300 psf.

C. Frames: Frame members shall be fabricated from 6063-T5 mill finish extruded aluminum angles with anchor flange around perimeter. Covers shall be reinforced to be capable of withstanding a uniform live load of 300 psf.

D. Coat concealed surfaces of aluminum in contact with grout, concrete, masonry or dissimilar metals with two (2) coats of bituminous paint.

E. Hatch opening swing orientation and lift handle location shall be oriented as directed by the Owner.

F. Acceptable manufacturers are: Bilco, Halliday Products, or Dur-Red Products

2.13 PIPE AND FITTINGS

A. Ductile Iron Pipe and Fittings
   1. Non-Buried Service (within wet well and valve vault)

a. Unless otherwise noted or required, all non-buried ductile iron piping shall be flanged pipe with threaded flanges in accordance with AWWA C115, latest revision. All piping shall be rated for 250 psi and flanges shall have ring or full-face gaskets, 1/8-inch thick, as recommended by the pipe manufacturer for the pipe size and service in which it is intended. All bolts, nuts and studs for flanged pipe in submerged locations shall be of 316 Series stainless steel.

b. All non-buried ductile iron pipe to be field painted shall be furnished with an external coating of rust inhibitive primer such as Tnemec Series N140; Tnemec Series 1 OmniThane; Sherwin-Williams Corothane I GalvaPac; or equal. Pipe manufacturer shall be responsible for compatibility of shop applied coatings with the field paint systems. Do not apply asphalt or bituminous coatings on pipe to be painted.

1. All ductile Iron Pipes and Valves within the wet well and valve vault shall be field painted after installation with Tnemec 66 HB Epoxy or approved equal.

c. The interior of all ductile iron pipe shall be double cement-mortar lined with bituminous seal coat in accordance with AWWA C104, latest revision. Thickness of the lining shall be as set forth in the aforementioned specification unless otherwise directed by the Engineer.

d. Ductile iron fittings shall conform to AWWA C110, latest revision, with flanges faced and drilled 125-pound. Fittings shall have interior lining and exterior coating same as the pipe.

2. Buried Service

a. Ductile iron pipe for buried service shall conform to the current requirements of AWWA C151, Pressure Class 350 (3-inch to 12-inch pipe) or Pressure Class 250 (14-inch pipe and larger), with push-on joints unless otherwise noted on Drawings.

b. Unless otherwise specified, the interior of the pipe shall be double cement-mortar lined with bituminous seal coat in accordance with the current requirements of AWWA C104. Thickness of the lining shall be set forth in the aforementioned specification unless otherwise directed by the Engineer. The exterior of all buried pipe, unless otherwise specified, shall receive either coal tar or asphalt base coating a minimum of 1 mil thick.

c. Each piece of pipe shall bear the manufacturer's name or trademark, the year in which it was produced and the letters "DI" or the word "DUCTILE". Pipe manufacturer shall furnish notarized certificate of compliance to the above AWWA specifications.

d. Fittings shall be ductile iron and rated for a minimum of 350 psi in accordance with the current requirements of AWWA C110 shown therein. Fittings shall have mechanical joints meeting the current requirements of AWWA C111. Fittings shall have interior cement-mortar lining as specified for the pipe. Compact ductile iron fittings meeting the current requirements of AWWA C153 will also be acceptable. Provide notarized certificate of compliance to the AWWA specifica-

tions.

e. Mechanical joints shall be bolted and of the stuffing box type and shall consist of a bell, with exterior flange and interior recess for the sealing gasket, a pipe or fitting plain end, a sealing gasket, a follower gland, tee-head bolts and hexagon nuts. All bolts and nuts shall be high strength, heat treated ASTM A36 or A-307 carbon steel as a minimum requirement. All bolts and nuts shall be fluoropolymer coated.

f. Gasket material for standard wastewater service up to 150°F shall be SBR (Styrene-Butadiene Rubber).

g. Provide locked or restrained pipe joints where indicated on Drawings. Fittings under structures shall be mechanical joint with retainer glands. Retainer glands shall be of the "wedge action" design, where tightening the screws causes the wedge to lock onto the pipe. Retainer glands shall be Mega-Lug as manufactured by EBAA Iron, Inc. or equal.

h. Buried pipe shall be installed with a polyethylene encasement confirming to AWWA C105. The encasement for force main service shall be green in color.

2.14 FLOW METERS – IF REQUIRED

A. Flow meters, where required, shall be Magflux by MJK or approved equal.

1. Meter inaccuracy shall be no more than 0.5% of actual flow rate for all flows above 1 foot per second.
2. Flow meter shall be suitable for operation at ambient temperatures from 40°F to 140°F.
3. Flow meter and transmitter shall be rated for accidental submergence.
4. Flow meters shall indicate, totalize, and transmit flow in full pipes.

2.15 PLUG VALVES

A. Non-Buried Service:

1. Plug valves shall be of the non-lubricated, eccentric type with resilient faced plugs and shall be furnished with flanged end connections. Valves shall have flanged ends faced and drilled to ANSI B16.1 125-lb. Standard.

2. Valves shall be rated for bi-directional working pressure up to 175 psig for valves up to 12" and 150 psig for 14" through 36". Valves shall provide drip-tight shutoff up to the full pressure rating. Every valve shall be given a certified hydrostatic and seat test, with test reports being available upon request.

3. Valve bodies shall be of the ASTM A536 Grade 65-45-12 ductile iron. Bodies shall be furnished with a 1/8" welded overlay seat of not less than 95% pure nickel. Seat area shall be ½" wide with raised surface completely covered with weld to ensure that the plug face only contacts the nickel. Screwed in seats shall not be acceptable.

4. The interior and exterior of the valve shall be coated with a fusion bonded epoxy.

5. Port areas shall be unobstructed when open and shall open to 100% of the standard class pipe area. All plug valves shall be provided with limit stops and rotate 90º from fully opened to fully closed.

6. Plugs shall be of the ASTM A126 cast iron or ASTM A536 ductile iron and rectangular. The plug shall have a cylindrical seating surface eccentrically offset from the center of the plug shaft. Plug shall not contact the seat prior to 90% closed. The interference between the plug face and body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. Plug shall be resilient faced suitable for use with sewage.

7. Valves shall have sleeve type metal bearings and shall be of sintered, oil impregnated permanently lubricated type 316 stainless steel. Non-metallic bearings shall not be acceptable.

8. Valve shaft seals shall be of the multiple V-ring type, with a packing gland follower. Shaft seals shall permit inspection, adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except the packing gland follower. Grit excluders shall be provided to prevent the entry of grit and solids into the bearing areas.

9. All valves 12" or less shall use lever actuators unless force main pressure is relatively high (to be determined on a case-by-case basis). All valves larger than 12" shall be equipped with gear actuators. All gearing shall be enclosed in a cast iron housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator. The actuator shaft and the quadrant shall be supported on permanently lubricated bronze bearings. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque and to provide adjustment to compensate for change in pressure differential or flow direction change.

10. All exposed (non-submerged) nuts, bolts and washers shall be stainless steel.

11. Plug valves shall be as manufactured by Val-Matic (Series 5600F), Dezurik (Style "PEF"); or equal;

B. Buried Service

1. Buried plug valves shall be of the non-lubricated, eccentric type with resilient faced plugs meeting the requirements of AWWA C517 and shall be furnished with mechanical joint ends and mechanical joint accessories meeting the requirements of AWWA C111. Valves and gear actuators for buried or submerged service shall have seals or all shafts and gaskets on the valve and actuator covers to prevent the entry of water. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs and washers shall be stainless steel.

2. Valves shall be rated for bi-directional working pressure up to 175 psig for valves up to 12" and 150 psig for 14" through 36". Valves shall provide drip-tight shutoff up to the full pressure rating. Every valve shall be given a certified hydrostatic and seat test, with test reports being available upon request.

3. Valve bodies shall be of the ASTM A536 Grade 65-45-12 ductile iron. Bodies shall be furnished with a 1/8" welded overlay seat of not less than 95% pure nickel. Seat area shall be ½" wide with raised surface completely covered with weld to insure that the plug face only contacts the nickel. Screwed in seats shall not be acceptable.

4. Port areas shall be unobstructed when open and shall open to 100% of the standard class pipe area. All plug valves shall be provided with limit stops and rotate 90º from fully opened to fully closed.

5. Plugs shall be of the ASTM A126 cast iron or ASTM A536 ductile iron and rectangular. The plug shall have a cylindrical seating surface eccentrically offset from the center of the plug shaft. Plug shall not contact the seat prior to 90% closed. The interference between the plug face and body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. Plug shall be resilient faced suitable for use with sewage.

6. Valves shall have sleeve type metal bearings and shall be of sintered, oil impregnated permanently lubricated type 316 stainless steel. Non-metallic bearings shall not be acceptable.

7. Valve shaft seals shall be of the multiple V-ring type, with a packing gland follower. Shaft seals shall permit inspection, adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except the packing gland follower. Grit excluders shall be provided to prevent the entry of grit and solids into the bearing areas.

8. Valves and gear actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water. All valves 4" and larger shall be equipped with gear actuators. Actuator mounting brackets shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs and washers shall be stainless steel. A 2-inch square nut operator in a vertical position shall be provided for use in a valve box. Contractor shall use extension stems, if necessary, to raise the operator nut within 3 ft. of final grade. A “Posi-Cap” high-strength plastic valve box aligner shall be installed within the valve box, centered about the extension stem and located under the operating nut.

9. The interior and exterior of the valve shall be factory coated with fusion bonded epoxy.

10. Buried plug valves shall be as manufactured by Val-Matic (Series 5700F), Dezurik (Style “PEF”); or equal;

11. Valve Boxes

    a. Valve boxes shall be of 5-1/4 inch standard cast iron, two-piece, screw type valve box with drop cover marked "SEWER", as applicable. Valve boxes for valves larger than 8 inches shall be three-piece. Valve boxes shall be accurately centered over valve operating nut, and backfill thoroughly tamped about them. Valve boxes shall not rest on the valves but shall be supported on crushed stone fill. They shall be set vertically and properly cut and/or adjusted so that the tops of boxes will be grade in any paving, walk or road surface, and 2 to 3 inches above finish grade in grass plots, fields, woods or other open terrain.

    b. Nut operator extensions for all valves buried deeper than 3 feet shall be provided with stem extensions sufficient to raise operator nut to within 3 feet of finished grade.

c. Wherever valve boxes fall outside of the pavement, the top of the box shall be set in a concrete slab 18” x 18” x 6” thick (or 18” circular x 6” thick) with the top of the slab and box flush with the top of the ground.

d. Valve boxes and covers shall be as manufactured by Tyler Corporation; Opelika Foundry; or equal.

2.16 SWING CHECK VALVES

A. Check valves shall be ductile iron body and domed access cover per ASTM A536 Grade 65-45-12, and flexible internal disc, rated for 150 psi working pressure. Flanges shall be faced and drilled in accordance with ANSI B16.1, Class 125 Standard. Valve shall be designed, manufactured, tested and certified to AWWA C508. All bolts and hardware shall be stainless steel.

B. Valve body shall have a full-flow equal to nominal pipe diameter at all points through the valve. The seating surface shall be on a 45-degree angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve to allow for installation of a backflow actuator without special tools or removing the valve from the pipeline.

C. The interior and exterior of the valve shall be coated with a fusion bonded epoxy.

D. The top access port shall be full size, allowing for removal of the disc without removing the valve from the pipeline. The access cover shall be domed in shape to provide flushing action over the disc for operation in lines containing high solids content.

E. The disc shall be of one-piece construction, precision molded Buna-N, with an integral o-ring type sealing surface, and contain steel and nylon reinforcement in the hinge. Non-slam closing characteristics shall be provided through a short 35-degree disc stroke and a memory disc return action.

F. A screw-type backflow actuator shall be provided for field installation to allow opening of the valve during no-flow conditions. Buna-N seals shall be used to seal the stainless steel stem in a bronze bushing. The backflow device shall be of the rising stem type to indicate position and furnished with a T-handle for ease of operation.

G. Swing check valves shall be as manufactured by Val-Matic (Swing-Flex Series #500), Dezurik (Series 100 Swing Check Valve); or equal;

2.17 SPARE PARTS

A. One (1) complete set of o-rings, mechanical seals, and impeller for each submersible pump.

2.18 SITE LIGHT

A. Pole light head shall be RAB Model ALED4T105/D10/WS2 or equivalent.
B. Pole (10-foot height) shall be RAB PS4-11-20D2 or equal.
C. Light pole shall be mounted per manufacturers requirements and include all applicable accessories (cap, base cover, mounting belts, etc.)

PART 3 - EXECUTION

3.1 WET WELL AND VALVE VAULT INSTALLATION

A. Granular material shall be placed and graded level in the bottom of the excavation prior to installation.

1. All joints shall be sealed watertight according to precast concrete manufacturer's direction.
2. Install external joint wraps on all wet well and valve vault joints.
3. If exterior coating is to be field applied, coat exterior surface below grade. Coat interior surface where indicated.
4. After exterior coating has adequately cured, backfill around wet well as needed for valve vault installation. Note that any backfill under the valve vault location shall be compacted granular material.
5. Install valve vault structure with a similar procedure to the wet well as describe above.
6. Test wet well in accordance exfiltration test in Item 3.4 C below.

3.2 PUMP AND PIPING INSTALLATION

A. All pumps and pumping equipment shall be installed per the manufacturer's recommendations.

B. During pump installation, the open power cable ends are to be suspended above the maximum flood elevation or maximum expected water level. If not installed in this manner, Contractor may be required to replace the pump motors and cables with new units to ensure that water has not penetrated the cable and entered the motor housing.

C. The discharge elbow of each pump shall be securely anchored to the wet well base and properly aligned with the guide system and upper guide bracket.

D. Piping

1. Materials shall be new and of the best grade and quality; workmanship shall be first class in every respect.

2. Each piece of iron pipe and each fitting shall be plainly marked at the foundry with class number and weight.

3. Where indicated on the Drawings, plain-end pipe shall be joined by means of flanged adapters or flexible couplings.

4. All pipe couplings shall be designed to safely withstand the operating pressure of the lines in which they are installed.

5. Taps and connections to piping shall be made as required to connect equipment, sample lines, etc., and where otherwise shown on the Drawings.

6. All pipe and fittings shall be shop primed with an approved rust inhibitive primer.

E. Field Painting

1. Field paint all new equipment, exposed pipe, valves, and fittings, submerged and exposed structural steel, exposed electrical conduits, miscellaneous metal items including galvanized steel, and aluminum surfaces in direct contact with concrete.
2. Do not field paint stainless steel, fiberglass, aluminum, grating, or items with special coatings.
3. Shop coats of paint or other protective coatings damaged in transit or during construction shall be touched up in the field with primer coat before start of finish coats.
4. Colors of paint where not specified shall be as selected by the Town.

3.3 ELECTRICAL INSTALLATION

A. Coordinate with local electric company to provide necessary power supply to the site.

B. Coordinate with Town and electric company for location of power poles, guy wires, power lines, transformers, easements, and location of electric meter.

C. Install power poles, guys, weatherheads, meter bases, service entrances, grounds, and other power supply items required by electric company for service.

D. Provide required power from electric meter to all electrical components and systems.

E. Install all electrical equipment within the station by a qualified electrician in conformance with the National Electric Code.

F. The site light shall be powered and switched from the control panel. Mounting and installation shall be per manufacturers requirements.

3.4 FIELD QUALITY CONTROL

A. Testing, General

1. Test new wet wells, controls, pumping, and pipe systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
2. Inspect and test completed pipe systems.
3. Schedule inspections and tests with Town representative and Engineer with at least 48 hours' advance notice.
4. Submit separate report for each test.
5. Any visible leaks, evidence of leaks, or malfunctioning or improperly functioning equipment or controls shall result in a failed test.
6. Failures of inspections or tests indicate defects that must be repaired or replaced.
7. Replace failed work using new materials, and repeat testing until test results are within allowances specified.

B. Cleaning

1. Conduct standard cleaning prior to acceptance testing.

C. Wet Well Exfiltration Test

1. Applicability

   a. All new wet wells shall be tested by a water exfiltration test.

   b. Test after:

      1) Installation with all pipe connections in place.

      2) Installation of all electrical conduits and other penetrations to the wet well structure.

      3) Plugging of all lift holes.

      4) Backfilling to design grade.

      5) Groundwater has been lowered to below the bottom of the wet well.

      6) Curing of any coating or lining applied to the interior of the wet well.

   c. Test before:

      1. Installation of pumps, electrical power and controls wiring, and other electrical and mechanical systems.

   d. An exfiltration test is not required for the valve vault however any observable active leaks within the valve vault shall be property sealed by the contractor as needed.

2. Procedure

   a. Seal all inlets and outlets with watertight plugs or bulkheads. The wet well vent shall be screened, capped, flanged, or otherwise blocked.

   b. Fill the wet well with water until the elevation of the water is above the interface of the concrete and the hatch frame. Clearly mark the test level in the wet well.

   c. Fill and maintain full of water for a period of at least 24 hours prior to the start of the test to allow for absorption of water by the concrete.

   d. Prior to initiation of the test, raise the water level to the test level mark.

   e. Conduct the test a minimum of 24 hours. Once the test begins, the hatch shall only be opened in the presence of Engineer.

   f. At the end of the test period, refill the wet well to the test level, measuring the volume of water added.

3. Determination of Wet Well Acceptance: If the volume of water required to refill the wet well to the initial test level is less than or equal to the following volumes, the wet well shall have passed the test.

   a. The maximum leakage allowance for unlined wet wells shall be 0.05% of the water volume per 24 hours.

   b. No leakage shall be allowed for lined wet wells.

4. Determination of Wet Well Failure: If the volume of water required to refill the wet well to the initial test level is more than the acceptable volumes, the wet well shall have failed the test.

5. Correction

a. If the wet well fails this test, locate defects and notify Engineer of findings. Repair or replace defects in a manner acceptable to Engineer.

b. After the defects are corrected, the wet well shall be re-tested per the test procedure above.

D. Pump and Controls Tests

1. All new lift station pumps and controls shall be tested.

2. Test after:

a. Installation of all electrical and mechanical systems have been completely installed, with all connections in place.

b. Completion and acceptance of force main(s) discharging from lift station.

c. Manufacturer's successful start-up of all mechanical, electrical, and controls systems.

1. Submit manufacturer's start-up records with request for testing.

d. Conduct the following in the presence of Engineer and Town representative:

1) Manually check floats' on/off operations, alarm/run lights, and alarm horns.

2) Check performance of control switches, alternators, and gauges.

3) Confirm proper functioning of the remote monitoring system.

4) Determine pump capacity for each pump individually and all pumps operating simultaneously.

5) Determine inflow rate (if any).

6) Perform full-cycle pump-down test of each pump. Check amperage draw of each leg of each pump motor.

7) Perform full-cycle pump-down test of all pumps. Check voltage at motor power cable connections.

END OF SECTION 11310

SECTION 16415
TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SCOPE

A. This section includes automatic transfer switches rated 600 V and less.

1.2 DEFINITIONS

A. ATS – Automatic Transfer Switch.

1.3 SUBMITTALS

A. Shop drawings and product data for each transfer switch, including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists.

B. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.

C. Single-line diagrams of transfer switch units showing connections between ATS, power source, and load, plus interlocking provisions.

D. Operation and maintenance data for each product. Include all features and operating sequences. List all factory settings of relays and provide relay setting and calibration instructions.

E. Manufacturer's certificate of compliance to the referenced standards and tested short-circuit closing and withstand ratings applicable to the project.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 for components and installation.

B. Manufacturer Qualifications

1. Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than 8 hours from time of notification.

2. ISO 9001 or 9002 certified.

C. The transfer switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards as follows:

1. NEMA ICS 1 - Industrial Control and Systems: General Requirements.

2. NEMA ICS 10 – AC Transfer Switch Equipment.

3. NFPA 70.

4. NFPA 110 – Emergency and Standby Power Systems.

5. UL 1008 unless requirements of these specifications are more stringent.

6. UL 991 - Tests for Safety-Related Controls Employing Solid-State Devices.

7. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems

8. IEC 801-2, 3, 4, and 5

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. ATS shall be manufactured by Cummins, Kohler, or approved equal.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30% of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings adequate for duty imposed by protective devices at installation locations in project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be +/- 2% or better over an operating temperature range of -20 to +70 °C.

D. Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical operation shall be by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switches shall be designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.

2. Switch action shall be double throw, mechanically held in both directions.

3. Contacts shall be silver or silver alloy for load-current switching. ATS units rated 225 A and higher shall have separate arcing contacts.

G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

H. Equip switches exposed to outdoor temperatures and humidity with an internal heater. Provide thermostat within enclosure to control heater.

I. Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

J. Train and bundle factory wiring and label consistent with shop drawings, either by color-code or numbered/lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.

2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.

3. Equip control wiring with lugs suitable for connection to terminal strips.

K. Enclosures

1. NEMA 4 stainless steel, non-painted where installed within an environmentally controlled structure.

2. NEMA 4X stainless steel, non-painted where installed in locations exposed to weather.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Double-throw switching arrangement, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

D. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the 2 sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70% or more of nominal voltage.

E. Automatic Transfer Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100% of nominal, and dropout voltage is adjustable from 75 to 98% of pickup value. Factory set for pickup at 90% and dropout at 85%.

2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from 0 to 6 seconds, and factory set for 1 second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100% of nominal. Factory set for pickup at 90%. Pickup frequency shall be adjustable from 90 to 100% of nominal. Factory set for pickup at 95%.

4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.

6. Switch-Position Pilot Lights: Indicate source to which load is connected.

7. Source-Available Indicating Lights: Supervise sources via transfer switch normal- and emergency-source sensing circuits.

a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: 2 normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240 V AC.

9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: 1 isolated and normally closed, and 1 isolated and normally open, rated 10 A at 32 V DC minimum.

11. Engine Shutdown Contacts: Time delay adjustable from 0 to 5 minutes, and factory set for 5 minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.

    b. Push-button programming control with digital display of settings.

    c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment to ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost if necessary to accommodate required wiring.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

C. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

1. Check for electrical continuity of circuits and for short circuits.

2. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

E. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least 3 times.

1. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

2. Simulate loss of phase-to-ground voltage for each phase of normal source.

3. Verify time-delay settings.

4. Verify pickup and dropout voltages by data readout or inspection of control settings.

5. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

6. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

F. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

1. Verify grounding connections and locations and ratings of sensors.

G. Coordinate tests with tests of generator and run them concurrently.

H. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

I. Remove and replace malfunctioning units and retest as specified above.

J. Perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of project completion.

2. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Coordinate this training with that for generator equipment.

END OF SECTION 16415

SECTION 16620
PACKAGED ENGINE GENERATORS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes packaged diesel-engine generator sets with the following features and accessories:

1. Dual wall fuel tank.
2. Engine-generator set.
3. Muffler.
4. Exhaust pipe external to set.
5. Outdoor enclosure.
6. Remote stop switch.

1.2 DEFINITIONS

A. Power Output Rating – Gross electrical power output of generator set minus total power requirements of electric motor-driven accessories normally constituting part of the engine assembly.

B. Operational Bandwidth – the total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

C. Steady-State Voltage Modulation – the uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.3 SUBMITTALS

A. Product Data:

1. Data on features, components, accessories ratings, and performance.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
3. Power, signal, and control wiring diagrams.

C. Qualification data for installer and manufacturer.

D. Test Reports:

1. Report of factory test on units to be shipped, showing evidence of compliance with specified requirements.
2. Report of sound generation.
3. Report of exhaust emissions showing compliance with applicable regulations.

4. Field quality-control test reports.

E. Certification of Torsional Vibration Compatibility indicating compliance with NFPA 110.

F. Operation and Maintenance Data:

1. For packaged engine generators.

2. Include a list of tools and replacement items recommended to be stored for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty:

1. Manufacturer's standard from in which manufacturer agrees to repair or replace components of packaged engine generators and associated components that fail within a period of 5 years from the date of substantial completion.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Firms experienced in manufacturing equipment of the type and capacity indicated with a record of successful in-service performance.

2. Maintain a service center within 200 miles of site capable of providing training, parts, and emergency maintenance repairs.

3. Not more than 4 hours normal travel time from manufacturer's place of business to site.

B. Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

C. Qualify welding procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

D. Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100.

E. Comply with NFPA 30.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Comply with NFPA 110 requirements for Level 2 emergency power supply system.

I. Engine exhaust emissions shall comply with applicable state and local government requirements.

J. Noise emission shall comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings or other protection that will exclude dirt and moisture and prevent damage from construction operations.

B. Remove protection only after equipment is safe from dirt, moisture, and damage.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering and identified with labels:

1. Fuses: 1 for every 10 of each type and rating, but not less than 1 of each.
2. Pilot Lights: 2 for every 6 of each type used, but not less than 2 of each.
3. Filters: 1 set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, products shall be by Cummins, Kohler, or approved equal.

2.2 ENGINE-GENERATOR SET

A. Packaged engine-generator set shall be a coordinated assembly of compatible components.

B. Comply with safety standards in ASME B15.1.

C. The generator shall be sized to start one pump to be installed while one pump is running, plus 5 kilowatts of load at 0.8 power factor, 480 volt, 3 phase, 60 hertz, within 25% voltage dip, as measured using an oscilloscope.

D. Output connection shall be 3 phase, 4 wire for 480Y/277 volt services.

E. Internal and external supports for components and fastenings for wiring and pipe are designed to withstand static or anticipated seismic forces in any direction. For each item, use a minimum force value equal to the item’s weight.

F. Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, model number, and serial number.

2.3 GENERATOR-SET PERFORMANCE FOR SENSITIVE LOADS

A. Voltage Regulation: 1% of rated output voltage from no load to full load.

B. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

C. Transient Voltage Performance: Not more than 10% variation for 50% step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

D. Frequency Regulation: 0.25% of rated frequency from no load to full load.

E. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

F. Transient Frequency Performance: Less than 2-Hz variation for a 50% step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 3 seconds.

G. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2% total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 5%.

H. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, the system shall supply a minimum of 300% of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

I. Performance of excitation system shall be unaffected by voltage distortion caused by nonlinear load.

J. Start time shall comply with NFPA 110, Type 10, system requirements.

2.4 SERVICE CONDITIONS

A. Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient temperature: 5°F to 104°F.
2. Relative humidity: 0% to 95%.
3. Altitude: Sea level to 1000 feet.

2.5 ENGINE

A. Fuel: Diesel.

B. Rated Engine Speed: 1800 rpm.

C. Comply with NFPA 37.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90% of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Diesel engine fuel systems include integral injection pumps, main fuel pumps mounted on the engine, fuel oil filters ahead of the injection pumps, and relief/bypass valve regulating pressure in the fuel line.

F. Jacket Coolant Heater: Electric type, factory-installed. Unit is rated and thermostatically controlled to maintain engine block temperature of 90°F. Provide an oil pressure cutout to turn the heater off when the engine is running. Provide shut-off valves on the engine side to allow for replacement of the heater and hoses without draining the system.

G. Speed Governor: Adjustable isochronous type with speed sensing.

2.6 ENGINE COOLING SYSTEM

A. Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

B. Radiator: Factory-piped and rated for specified coolant.

C. Coolant: Solution of 50% ethylene-glycol-based antifreeze and 50% water.

D. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

E. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

1. Rating: 50-psig maximum working pressure with coolant at 180°F, and non-collapsible under vacuum.

2. End Fittings: Flanges or steel pipe nipples with clamps to suit pipe and equipment connections.

2.7 DIESEL FUEL SUPPLY SYSTEM

A. Comply with NFPA 30.

B. Dual wall sub-base fuel tank sized to support the generator set for 24 hours at 100% of rated load.

2.8 ENGINE EXHAUST SYSTEM

A. Muffler shall be sized as recommended by engine manufacturer. Sound level measured at a distance of 10 feet from exhaust discharge shall be 85 dBA or less.

B. Condensate drain for muffler shall be Schedule 40 black steel pipe connected to muffler drain outlet through a petcock.

C. Exhaust pipes per NFPA 37.

2.9 COMBUSTION-AIR INTAKE

A. Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

2.10 STARTING SYSTEM

A. 12 or 24 volt DC electric with negative ground. Include the following items:

1. Components sized so they will not be damaged during a full engine-cranking cycle.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery cable sized as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

5. Battery heater shall be 120 volt heater capable of maintaining battery temperature at 50°F.

2.11 CONTROL AND MONITORING

A. When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of the generator set. When mode-selector switch is switched to the on position, the generator set starts. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

B. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common UL-listed control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

C. Indicating and Protective Devices and Controls:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Generator overload.

D. Supporting items include sensors, transducers, terminals, relays, and other devices and wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

E. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.
2. Lube-oil low-pressure shutdown.
3. Overspeed shutdown.
4. Remote emergency-stop shutdown.
5. Engine high-temperature prealarm.
6. Lube-oil low-pressure prealarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.
9. Overcrank shutdown.

10. Coolant low-temperature alarm.
11. Control switch not in auto position.
12. Battery-charger malfunction alarm.
13. Battery low-voltage alarm.

F. Remote emergency-stop switch shall be protected from accidental operation.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 80% rated; complying with NEMA AB 1 and UL 489.
1. Trip rating as shown on the Contract Drawings.
2. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
3. Mount adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, Article 700-7(d). Integrate ground-fault alarm indication with other generator-set alarm indications if shown on the Contract Drawings.

2.13 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and specified performance requirements.

B. Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical insulation shall be Class H or Class F.

D. Stator-Winding Leads shall be brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125% of rating, and heat during operation at 110% of rated capacity.

F. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.

G. Enclosure shall be drip-proof.

H. Instrument transformers shall be mounted within generator enclosure.

I. Voltage regulator shall be solid-state type, separate from exciter, providing performance as specified.
1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5% adjustment of output-voltage operating band.

J. Strip heater shall be thermostatically controlled unit arranged to maintain stator windings above dew point.

2.14 OUTDOOR GENERATOR-SET ENCLOSURE

A. Sound-attenuated, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110% of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

C. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

D. Convenience Outlets: Factory wired and arranged for external electrical connection.

2.15 FINISHES

A. Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.16 SOURCE QUALITY CONTROL

A. Comply with NFPA 110, Level 1 energy converters.

B. Generator tests shall comply with IEEE 115.

C. Use instruments calibrated within the previous 12 months and with accuracy directly traceable to National Institute of Standards and Technology (NIST).

D. Perform hydrostatic test on radiator, heat exchanger, and engine water jacket.

E. Complete system operation test:

1. Nonstop operation for 4 hours minimum, including 1 hour at 1/2 load, 1 hour at 3/4 load, and 2 hours at full load.

2. If unit stops during test, repeat the complete test.

3. Record the following data at the start and end of each load run and at 15-minute intervals between those times:

a. Lubricating oil temperature and pressure.

b. Generator load current and voltage, each phase.

c. Generator system net output kW.

F. Complete system performance test:

1. Include the following to demonstrate conformance to specified performance requirements:

a. Single-step load pickup.

b. Transient and steady-state governing.

c. Transient and steady-state voltage performance.

d. Safety shutdown devices.

G. Provide 2 weeks advance notice of tests and opportunity for Town representative to observe testing.

H. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of pipe systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Coordinate size and location of concrete bases with manufactures requirements. Verify structural requirements with structural engineer.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Field install pipe and ductwork as indicated on the drawings.

C. Maintain minimum working space around components according to manufacturer’s shop drawings and NEC.

D. Install packaged engine generators level on concrete base.

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Install cooling-system pipe, accessories, hangers and supports, and anchors for complete installation.

G. Install exhaust-system pipe. Extend to point of termination outside structure. Size pipe according to manufacturer's written instructions.

H. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

I. Arrange and pay for the services of a factory-authorized representative to supervise installation, connections, testing, and adjusting of the unit.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of pipe and specialties. The following are specific connection requirements:

1. Install fuel, cooling-system, and exhaust-system pipe adjacent to packaged engine generator to allow service and maintenance.

2. Connect cooling-system water supply and drain pipe to diesel-engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.

3. Connect fuel pipe to engines with a gate valve and union.

4. Connect exhaust-system pipe to engines.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.15.2.1 and 7.22.1 (except for vibration baseline test). Certify compliance with test parameters.
2. Perform tests recommended by manufacturer.
3. Perform tests required by NFPA 110.
4. Verify proper installation, connection, and integrity of each element of engine-generator system before and during operation. Check for air, exhaust, and fluid leaks.
5. Exhaust Emissions Test: Comply with applicable test criteria.
6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50% and 100% step-load increases and decreases and verify that performance is as specified.
7. Harmonic-Content Tests: Measure harmonic content of output voltage under 25% and at 100% of rated linear load. Verify that harmonic content is within specified limits.
8. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at 4 locations on the property line, and compare measured levels with required values.
9. Simulate malfunctions to verify proper operation of protective, alarm, and monitoring devices.
10. Operate nonstop for a minimum of 4 hours, including 1 hour at 1/2 load, 1 hour at 3/4 load, and 2 hours at full load. If unit stops during the test, repeat the complete test. Record the following minimum data at the start and end of each load run, and at 15-minute intervals between those times:
    a. Lubricating oil temperature and pressure
    b. Generator load current and voltage, each phase.
    c. Generator system net output kW.

B. Coordinate tests with tests for transfer switches and run them concurrently.

C. After installation, charge system and test for leaks. Repair and retest until no leaks exist.

D. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Remove and replace malfunctioning units and retest as specified above.

G. Correct deficiencies identified by tests and observations and retest until specified requirements are met.

H. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 STARTUP SERVICE

A. Upon complete installation and inspection of system components, remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars to finish to match original finish. Clean components internally using methods recommended by manufacturer.

B. Engage a factory-authorized service representative to perform startup service.

C. Inspect field-assembled components and equipment installation, including pipe and electrical connections. Report results in writing.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain packaged engine generators.

1. Coordinate this training with that for transfer switches.

END OF SECTION 16620