ANDERSON ENGINEERING, INC

EMPLOYEE OWNED

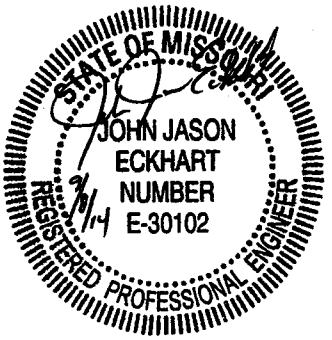
MAR 23 2015

STANDARD SPECIFICATIONS

for

SEWER MAIN CONSTRUCTION
CARTHAGE WATER AND ELECTRIC PLANT

CARTHAGE, MISSOURI



Department of Natural Resources
APR 13 2015
APPROVED

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September 2014

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CIVIL ENGINEERING • SURVEYING • STRUCTURAL • MUNICIPAL • GEOTECHNICAL/DRILLING • MATERIALS TESTING

LIST OF REVISIONS – Nov. 2011

SPECIFICATIONS

Description	Section	Modification
General	01010	Added Buy American Clause
Precast Manholes	02601	Revised paragraph 2.10
		Deleted Manhole Steps
		Deleted Chimney Seal
Sanitary Sewer Systems	02722	Added Tracer Wire to Laterals

DRAWINGS

Description	Dwg. No.	Modification
Precast Manhole (Eccentric)	SEW-5	Revision 1
Precast Manhole (Flattop)	SEW-6	Revision 1
Manhole Base (Precast)	SEW-7	Revision 1
Manhole Base (Cast-in-place)	SEW-8	Revision 1

LIST OF REVISIONS – May 2013

SPECIFICATIONS

Description	Section	Modification
Sewer and Manhole Testing	02749	Revised paragraph 4.1

LIST OF REVISIONS – July 2014

SPECIFICATIONS

Description	Section	Modification
Trenching, Backfilling and Compacting	02221	Revised paragraph 3.2.1
Granular Stone Bedding and Backfill	02222	Revised paragraph 3.1
Precast Manholes	02601	Revised paragraph 3.3.7
		Added paragraph 3.3.1(c)
Sanitary Sewer Systems	02722	General revisions
Sewer and Manhole Testing	02749	Revised paragraph 2.4
		Added paragraph 4.2

LIST OF REVISIONS – September 2014

SPECIFICATIONS

Description	Section	Modification
Sanitary Sewer Systems	02722	Added paragraph 3.10.1 (a)

TABLE OF CONTENTS

SPECIFICATION INDEX

Description	Section
General	01010
Unit Prices	01151
Cleaning	01710
Clearing and Grubbing	02110
Removal of Existing Improvements	02125
Trenching, Backfilling, and Compacting	02221
Granular Stone Bedding and Backfill	02222
Granular Stone Base	02223
Explosives	02225
Compaction Control and Testing	02250
Finish Grading	02260
Pipe Boring and Jacking	02300
Shoring	02400
Surface Restoration	02480
Asphaltic Concrete Paving	02513
Dewatering	02530
Roadway Surface and Sidewalk Replacement	02575
Precast Manholes	02601
Ductile Iron Pipe and Fittings	02615
Plastic Pipe and Fittings	02622
Sanitary Sewer Systems	02722
Sewer and Manhole Testing	02749
Concrete Formwork	03100
Concrete Reinforcement	03200
Cast-In-Place Concrete	03300
Concrete Admixtures	03301

STANDARD DRAWING INDEX

Description	Dwg. No.
General Notes	SEW-1
Trench & Bedding	SEW-2
Trench & Bedding (Pavement)	SEW-3
Manhole Plan	SEW-4
Precast Manhole (Eccentric)	SEW-5
Precast Manhole (Flattop)	SEW-6
Manhole Base (Precast)	SEW-7
Manhole Base (Cast-in-place)	SEW-8
Outside Drop	SEW-9
Existing Manhole Connection	SEW-10
Service Lateral (Stack)	SEW-11
Service Lateral (Runout)	SEW-12
Service Reconnection	SEW-13
Thrust Block	SEW-14
Water Line Crossing	SEW-15

1. GENERAL

1.1 Standard specifications for the work shall consist of the "Standard Specifications for Sewer Main Construction" of the Carthage Water and Electric Plant, City of Carthage, and specific sections from the "Standard Specifications for Highway Construction" of the Missouri Highway and Transportation Commission.

1.2 A Performance and Maintenance Bond shall be on file with the Public Work's Department prior to the start of the public improvement construction.

1.2.1 The Performance and Maintenance Bond shall be for the cost of the public improvement construction.

1.2.2 The Performance Bond shall be in effect until project completion. The Maintenance Bond shall be effective for a 12-month period following project completion and acceptance by the City of Carthage.

1.3 No public improvement project construction shall begin until a set of engineering drawings of the proposed construction; sealed by a licensed professional engineer registered in the State of Missouri, is received by the City of Carthage and approved by signature of the Public Works Director or his designee.

1.4 Any public improvement which will be located in a State of Missouri right-of-way shall be permitted first by the Missouri Department of Transportation (MoDOT) before being considered by the City of Carthage. A copy of the MoDOT permit shall be supplied to the City of Carthage.

1.5 All public improvement construction shall be performed in accordance with specifications listed herein and shall be inspected and documented by the City of Carthage Public Works Department.

1.6 If the public improvement construction is required to be done after normal working hours, or on weekends or holidays, all overtime pay for Public Works inspector shall be paid for by the contractor. Failure to pay overtime fees shall result in a claim against the project Performance Bond.

1.7 The contractor or owner will be responsible for the repair/replacement of any City facilities damaged during construction. Failure to repair/replace damaged City facilities will result in a claim against the contractor/owner's liability insurance policy.

1.8 For new construction projects, an emergency contact with a 24 hour telephone numbers must be on file in case of emergency.

2. SEWER MAIN IMPROVEMENTS

2.1 Sewer lines shall be completed to comply with the standards contained herein, with the requirements of the Missouri Department of Natural Resources, and all design standards and specifications now or hereafter promulgated by the Public Works Director or adopted by the Council, in accordance with the final construction plans required to be approved prior to final plat approval.

2.2 Responsibility for improvements costs: All costs for sewer line construction including testing and certification shall be the responsibility of the owner/developer.

3. TRAFFIC CONTROL

3.1 General. Materials, placement, maintenance, and removal of Traffic Control Devices shall be governed by Part 6 of the "Manual of Uniform Traffic Control Devices," published by the U.S. Department of Transportation of the Federal Highway Administration.

3.2 Maintenance of Access – Construction Sequence. The Contractor shall strictly adhere to the construction sequence outlined on the Construction Phasing Plans.

3.3 Placement of Devices – Approximate Quantities. In order to maintain safe work and travel in the construction zone, the Contractor shall provide and install signs, barriers, and lane channelization for vehicles as shown on the Traffic Control Plan.

4. QUALITY ASSURANCE

4.1 Developer/Contractor shall provide to City Engineer test reports from independent testing laboratory confirming lines, manholes, sub-grade, granular stone base, granular stone bedding, and pavement have been constructed in conformance with the appropriate City Specifications. The City Engineer or City Inspector shall be notified at least 24 hours prior to a scheduled inspection or test. Costs for independent testing of all components shall be the responsibility of the developer. Trench backfill and pipe bedding under streets shall be tested and inspected prior to construction of streets. Following construction, the project engineer shall provide signed approval stating to City that sewer lines and appurtenances have been constructed in accordance with approved plans and specifications.

1. GENERAL

1.1 This section described the methods of measurement and payment for the various items required by the specifications. There shall be no measurement or separate payment for any items not listed in the proposal and all costs pertaining thereto shall be included in the contract unit prices for other items listed in the proposal.

2. MEASURED ITEMS

2.1 Pipe Boring and Jacking: Underground excavation accomplished by tunneling, boring or jacking shall be measured and paid for on a per foot basis for the applicable size of cast or ductile iron pipe. Total length of excavation shall be as denoted on the plans or in the bid schedule based on the horizontal length of pipe measured from end to end of tunnel liner or casing pipe along centerline of pipe sewer. The bid price shall constitute full compensation for all labor, material, equipment, and for the performance of all work necessary to complete the sewer, including all excavation, sheeting and shoring, dewatering, installation of casing pipe or tunnel liner plates, grouting, installation of carrier pipe, sand fill, end seals, and disposal of excess material.

2.2 Surface Restoration: Shall be measured and paid for on a per linear foot basis for the type of restoration required. The width of the area to be restored shall be determined by each individual installation with all disturbed areas being restored. The bid price shall constitute full compensation for all materials, equipment, labor, supervision and incidentals necessary to complete the required restoration.

2.3 Roadway and Sidewalk Replacement:

2.3.1 Roadway surface replacement shall be measured and paid for on a linear foot basis as noted in the bid schedule. Stated bid price shall include all materials, equipment, labor and supervision required to complete roadway surface replacement.

2.3.2 Sidewalk replacement shall be measured and paid for on a linear foot basis as noted in the bid schedule. Stated bid price shall include all materials, equipment, labor and supervision required to complete sidewalk replacement.

2.4 Precast Manholes:

2.4.1 Type 1 Manholes: Shall be measured and paid for on a "per each" basis, regardless of depth. The bid price shall include all materials, equipment, labor and supervision required to install the manholes.

2.4.2 Type 2 Manholes: Shall be measured and paid for on a "per each" basis. The bid price shall include all materials, equipment, labor and supervision required to install the manholes.

2.4.3 Manhole Drop: Shall be measured and paid for on a "per each" basis. The bid price shall include all materials, equipment, labor and supervision required to install the outside drops regardless of the type of pipe material required.

2.4.4 Manhole over existing line: Shall be measured and paid for as denoted in paragraphs 2.4.1 and 2.4.2. No additional compensation will be allowed for this type of installation.

2.4.5 Connection to existing manholes: Shall be measured and paid for as a "per each" lump sum. The lump sum bid price shall include all materials, equipment, labor and supervision required to complete the connection to the existing manhole.

2.5 Sanitary Sewer:

2.5.1 Open Trenched: Measurement of various size, type, and depth will be in linear feet, as listed in the proposal, based on the horizontal length of pipe measured from center to center on manholes and to inside faces of special structures, along the centerline of sewer pipe. Depth range as listed in the proposal and shown on the plans will not be measured unless changed field conditions result in a change in the plans by the Owner.

2.5.2 Payment will be made at the contract unit price per linear foot for the applicable size, type, and depth of pipe sewer, as listed in the proposal. Such payment and price shall constitute full compensation for all the labor, materials, equipment, and for the performance of all work necessary to complete the sewer, including excavation, sheeting and shoring, dewatering, preparation of stone subgrade, installation of pipe sewer, backfilling, disposal of excess material, and replacement of pavement.

2.5.3 Encasement: Standard concrete encasement will be measured in linear feet for the applicable size pipe, as listed in the proposal, based on true length of encasement measured along the centerline of pipe. Concrete collars placed with adjacent encasement will be measured as one (1) linear foot of concrete encasement. Where concrete collars only are required, measurement will be made on a per each basis.

2.6 Sewer and Manhole Testing:

2.6.1 Pneumatic testing of completed sewer lines shall be measured and paid for on linear foot basis as listed in the proposal, based on the horizontal length of pipe measured from center to center of manholes and to inside faces of special structures, along the centerline of sewer pipe. Such payment and price shall constitute full compensation for all the materials, equipment, labor, and supervision for the performance of all work necessary to complete pneumatic testing of the sewers.

2.6.2 Hydrostatic or vacuum testing of manholes shall be measured and paid for on a "per each" basis as listing in the proposal. Such payment and price shall constitute full compensation for all the materials, equipment, labor, and supervision for the performance of all work necessary to complete hydrostatic or vacuum testing of the manholes.

CLEANING 01710

1. GENERAL

1.1 The work of this section consists of the periodic removal of construction debris from the job site(s) and associated public streets, roads, easements, and right-of-way used during construction. In addition, the final detailed cleaning of the site prior to the Owner's acceptance of the project is included.

2. MATERIALS

2.1 None.

3. METHODS

3.1 General: The Contractor shall keep the construction site sufficiently clean so as to allow a safe and expeditious construction operation to be implemented. Periodically and upon completion of the work and before acceptance and final payment is made, the Contractor shall clean and remove from the road rights-of-way, easements, public and private property, all surplus, discarded materials, perishable matter, rubbish and temporary structures. He shall restore in an acceptable manner all property, both public and private, which may have been damaged on account of the prosecution of the work, and shall leave the roadway, easements, public and private property neat and presentable.

3.2 Open-burning: During each construction project phase, efforts shall be taken to prohibit the open burning of refuse in accordance with laws and regulations of the applicable municipal and state agencies.

3.3 Dust Control: Construction operations may require control measures to prevent the creation of excessive dust, which will be the responsibility of the Contractor.

3.4 Water Pollution Control: The Contractor shall exercise caution to guard against the degradation of the waters of the State of Missouri due to construction related pollutants (silt, debris, and petroleum products), and shall prevent the discharge of sewage involved with this contract into the waters of the State of Missouri.

CLEARING AND GRUBBING 02110

1. GENERAL

1.1 Description: The work in this section consists of furnishing all labor, materials, equipment, and tools necessary for performing all operations for the proper execution of all clearing and grubbing within the construction areas shown on the drawings and as necessary to complete this section.

1.2 Limits: Unless noted otherwise on the drawings, clearing and grubbing shall be performed within the limits of the "Permanent Easement" as shown on the drawings. Incidental clearing and grubbing shall be performed as necessary within the limits of the "Construction Easement" as shown on the drawings.

2. MATERIALS

2.1 None.

3. EXECUTION

3.1 Clearing:

3.1.1 Clearing shall consist of clearing the surface of the ground in the designated areas of all trees, stumps, roots, down timber, logs, snags, brush, undergrowth, hedges, heavy growth of grass or weeds, fences, structures, foundations, debris and rubbish of any nature.

3.1.2 Trees, stumps, roots, brush, and other vegetation in the areas to be cleared shall be cut below the original ground surface.

3.1.3 Trees and vegetation designated in the field by the Owner to remain standing shall be protected from any damage incidental to the clearing, grubbing, and construction operations.

3.2 Grubbing:

3.2.1 Grubbing shall consist of the removal and disposal of stumps, roots larger than two (2) inches in diameter, and matted roots from the areas designated to be grubbed. This material shall be removed to a depth of no less than twelve (12) inches below the original surface of the elevation.

3.2.2 Depressions created by grubbing operations shall be filled with suitable material and compacted.

3.3 Disposal of Materials:

3.3.1 All cleared and grubbed material including trees, stumps, roots, vegetation, organic material, rubbish, and otherwise shall be removed from the project site and disposed of in accordance with federal, state, and local laws.

3.3.2 Limited burning of debris on the site will be permitted if allowed by local, state, and federal law. Any ashes and/or debris left as a result of burning shall be removed from the site and taken to a landfill.

REMOVAL OF EXISTING IMPROVEMENTS 02125

1. GENERAL

1.1 This work shall consist of the removal and disposal of all existing improvements, except those designated or permitted to be left in place or to be removed under other items of work, from the right-of-way and within the limits of the project.

1.2 Removal of existing improvements shall include removing all buildings, drainage structures, pavements, surfacing and base courses of all types, curb, curb and gutter, sidewalks and house walks, steps, retaining walls, foundation walls, columns, footings, floors and any other types of building appurtenances, cisterns, catch basins, manholes, drainage and sewer pipes, water and gas main pipes, other objects or structures including scattered or piled bricks, stones, broken masonry, rubbish, debris, etc. from building demolition work, and other existing improvements. This item shall also include the salvaging of materials as designated in the contract, and the backfilling of the resulting trenches, holes, and pits, and any grading work required to shape, smooth, and finish the disturbed areas.

2. MATERIALS

2.1 None.

3. EXECUTION

3.1 All buildings, disused structures, old pavements, abandoned sewers or pipe lines, or other obstructions to the construction of the roadway or within the limits of the right-of-way and not designated or permitted to remain shall be removed or disposed of by the Contractor as required. Existing structures used for handling temporary traffic shall not be removed until the replacement structures are open to traffic. The Contractor may make use of existing structures or portions of them during construction, but no material designated for use elsewhere shall be removed from the project, cut, bent, broken, or otherwise damaged.

3.2 Material designated in the contract to be salvaged from existing structures shall be removed without damage in sections which may be readily handled or transported, and shall be piled neatly at an accessible point. Material not designated for salvage will be considered the property of the Contractor unless owned and claimed by any political subdivision or utility company. Salvaged materials becoming the property of the Contractor shall not be stored upon the right-of-way, nor shall any portion of the right-of-way be used by the Contractor as a sales yard. All discarded materials or debris shall be disposed of at locations furnished by the Contractor, or at locations on the right-of-way approved by the Engineer.

3.3 In removing pavement, curb, curb and gutter, gutters, sidewalk, and other similar improvements, and where a portion of such improvements are to be left in place, they shall be removed to an existing joint or to a joint sawed to a minimum depth of one inch with a true line and vertical face. Sufficient removal shall be made to provide for proper grades and connections in the new work regardless of any limits which may be indicated on the plans.

3.4 Removal of concrete pavement or base course and concrete sidewalk may consist either of breaking up and disposing of the broken concrete in embankments or in disposal areas furnished at the Contractor's expense, or of breaking the slab into pieces not exceeding 4 square feet where new embankment over 24 inches high is to be placed over the slab. Existing improvements not removed in their entirety shall be removed to a minimum depth of 12 inches below the finished grading section or natural ground.

3.5 All sewers and drainage pipes which have been or are to be abandoned shall be permanently sealed at the ends with bulkheads constructed of Class B Concrete, concrete of a commercial mixture or brick masonry, having a minimum thickness of 8 inches. The use of salvaged brick will be permitted for

constructing bulkheads provided the brick are clean and sound. No direct payment will be made for blocking abandoned sewers, drainage pipes, or floor drains.

3.6 All trenches, holes, and pits resulting from the removal of existing improvements shall be filled with earth. The material shall be placed in the same manner and compacted to approximately the same density as that required in adjoining areas.

3.7 Removing and disposing of abandoned fences will be considered as included in final cleaning up of the right-of-way and no direct payment will be made for such work.

4. MEASUREMENT AND PAYMENT

4.1 Measurement: Removal of existing improvements provided herein will be measured as a lump sum item for payment. This shall include the removal of all items, whether in view or hidden underneath the surface of the ground, regardless of whether shown on the plans or encountered during construction.

4.2 Payment: Removal of existing improvements will be paid for at a lump sum price and will include all incidentals.

1. GENERAL

1.1 Description: The work of this section consists of excavation for trenches relating to the construction of underground piping. There will be no distinction made in any definition or classification of excavation covered by this section between wet or dry materials below the surface of the earth. Trench excavation shall consist of all materials of whatever character encountered in the work, including soil, solid rock, fragmented rock, water, or other. Work under this section shall also include:

1.1.1 All sheeting, shoring, bracing, protection of adjacent property, preparation of all sub-grades, storage of excavated materials, backfilling, tamping, grading, and surfacing.

1.1.2 Diversion of surface water, and all pumping, draining, or other means of dewatering excavations.

1.1.3 All subsequent handling and disposal of excavated material, together with the preparation of all trench sub-grades.

1.2 Protection of Adjacent Property: The Contractor shall protect all excavations and trenches from settlement or displacement by approved means of bracing and shoring. All existing underground utilities and structures as well as all surface improvements and structures shall be protected and their functional purpose preserved.

2. CLASSIFICATION OF EXCAVATION

2.1 All excavation shall be considered as unclassified unless solid rock excavation is specifically denoted on the drawings and in the bid schedule.

2.2 Solid rock excavation shall denote all materials which cannot be removed by conventional excavating equipment and must be removed by jack hammering or blasting. Solid rock excavation shall only be measured and paid for when denoted on the plans and in the bid schedule.

3. TRENCHING

3.1 Lines and Grades: The Contractor shall furnish and set all stakes to establish and maintain the lines and grades as shown on the drawings including all grade boards, uprights, and accessory materials required. Line and grade shall be maintained either by grade boards with string or laser beam.

3.1.1 Grade boards shall be installed across the trench at intervals not to exceed 25 feet. The Contractor shall be held responsible for verification of lines and grades as established and shown on the drawings. The Owner may check the line and grade at any given point before backfilling has been started, and if there is a variation of more than two-hundredths (0.02) of a foot from the true grade, the same shall be raised or lowered as required.

3.1.2 In the event a laser beam is used to set line and grade for the pipe laying operation, grade stakes shall be set at each structure (i.e. catch basin, drop inlet, manhole, etc.) and at 25 feet, 50 feet, 100 feet, and then 100-foot increments thereafter, upgrade of the structure. The laser must be checked at the beginning of each day and at each grade stake to insure the proper line and grade of the pipe.

3.2 Excavation: All excavation for trenches shall be made with a sufficient working space to permit the placement, inspection, and completion of all work contemplated in the contract. Excavated material that is unsuitable for backfill, and all boulders exposed by grading shall be removed from the work area. Trenches shall be excavated in accordance with the drawings for trench width relative to trench depths.

3.2.1 Trenches shall be excavated to six inches below the bottom of the pipe when set to established flow lines. Should the trench be excavated more than six inches below the bottom of the pipe, the Contractor shall use only granular stone bedding material to establish flow line grade. All ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of four inches (4") below and on each side of all pipe(s).

3.2.2 Trench excavation shall, in all cases, be made continuous from the ground surface to the established trench depth. Materials excavated shall be stockpiled at the sides of the trench and within established area limits so as to minimize inconvenience to the public, and damage to vegetation and structures in the area.

3.2.3 Trenching, shoring, bracing, and shields shall be placed by the Contractor whenever necessary for the proper preservation of any excavation, embankment, or structure. Where the ground is of such a character or other conditions are such as to render it necessary, the sheeting shall be closely driven and to such depth below the lowest point of the final excavation as may be directed. The Contractor shall be held responsible for the sufficiency of all sheeting and bracing used, and for any and all persons injured, or property damaged as the result of improper quality, strength, placement, maintenance, or removal of the same. No extra compensation will be made for sheeting and bracing, whether left in place or not. The Contractor shall, at his own expense, shore up, protect, and insure from injury all building, retaining walls, piers, and footing, storm sewers, sanitary sewers, gas lines, water lines, fences, curbs, trees, or other property liable to be injured during the process of the work, and he will be held responsible for all damage which may occur by reason of prosecution of the work. Sheeting, shoring, and bracing shall be provided, installed, and maintained to protect the excavation, insure the safety of workmen, and as required by applicable federal, state, and local laws, rules, and regulations.

3.2.4 Trench width from six inches below the bottom of the pipe to six inches above the pipe bell shall be held to 1.4 times the outside diameter of the pipe plus twelve inches. Trench width above these levels may be wider to accommodate shoring, bracing, and shields, but shall be kept within practical limits. Contractor shall not receive additional payment for extra trench width.

3.3 Removal of Water: The Contractor shall furnish and operate sufficient pumps and appliances, and shall provide all material, labor, etc. required to prevent interference with any work by water, ice, or snow. Damage of any kind resulting from insufficient pumping facilities or similar lack of proper conduct of the work shall be made good by the Contractor at his own expense. No structure or pipe shall be placed in water and water shall not be allowed to run into or cover any concrete work or pipe, or into or through any pipe, unless by special permission given by the Owner in writing.

3.4 Record Drawings: Whether all excavations are considered unclassified or rock excavation is classified, the Contractor shall clearly indicated on the Record Drawings (which he shall submit to the Owner) the elevations and extent of all solid rock encountered during construction of the project.

4. BACKFILLING AND COMPACTING

4.1 Material used for backfilling of trenches shall be free from perishable matter and from other material liable to become unstable when saturated with water after having been compacted. No frozen material shall be used in backfill. No large stones or organic matter shall be placed within two feet of the top of the sewer pipe. Care shall be taken to prevent damage to the pipe and structures. Special precautions shall be taken in backfilling over pipes. No backfill shall be placed over any portion of pipes and/or joints not inspected by the Owner. The granular stone bedding material shall be brought to a depth of at least six inches over the top of the pipe bell, with this material carefully deposited in uniform layers not exceeding six inches in depth, and each layer carefully and solidly tamped with mechanical tampers in such a manner as to avoid damage to pipe or disturbing completed work. Unless noted otherwise on the drawings, backfilling for the remainder of the trench shall be previously excavated gravel, sand, or earth, and shall contain no stone over three inches in its largest dimensions. Stones smaller than that size may be used in proportion not exceeding one part of stone and three parts of earth in any place. This

backfilling shall be deposited and spread in layers and solidly tamped. As the trenches are backfilled, the Contractor shall remove all surplus material and re-grade the surface leaving it in good order. The trenches shall be filled to the ground surface elevation which previously existed, unless shown otherwise on the drawings.

4.1.1 The Contractor may be required to settle certain backfill material with water, in addition to other backfilling procedures. The water will be furnished by the Contractor without cost to the Owner. Methods and procedures in using the water shall be approved by the Owner prior to carrying out the operation.

4.1.2 Whenever, in the opinion of the Owner, the excavated material is not suitable for backfilling the trench, or there is a deficiency of material, the Contractor shall, as his own expense, provide suitable material.

4.1.3 All excess excavation materials shall be cleaned up by the Contractor as directed. All backfilled trenches shall be maintained by the Contractor for a period of one year after Final Acceptance of the work by the Owner.

4.1.4 Roadway Crossings: At all open-cut roadway crossings, and as noted elsewhere, the trench shall be backfilled to grade with granular stone meeting the requirements of Section 02222 - GRANULAR STONE BEDDING AND BACKFILL. For roadway surface replacement, see Section 02575 - ROADWAY SURFACE AND SIDEWALK REPLACEMENT.

4.1.5 Private Drives, Field Entrances, etc.: At all open-cut crossings of private drives, field entrances, and the like, the trench backfill shall be deposited and spread in layers and solidly tamped to Range "B" compaction requirements set forth in Section 02250 - COMPACTION CONTROL AND TESTING. Private drives, etc. shall be backfilled "immediately" upon completion of the pipe laying across the drive. The driving surface shall be restored to its original condition immediately following proper compaction of the backfill.

1. GENERAL

1.1 Description: The work in this section shall consist of furnishing, hauling, placing, and compacting granular stone for bedding underground utility piping, and for granular stone backfill at street crossings and other locations shown on the drawings.

2. MATERIALS

2.1 Pipe Bedding: Embedment for PVC gravity sewer pipe in ordinary trench conditions with or without high groundwater and with or without a hydraulic gradient shall be ASTM D2321 Class IB dense graded, clean, manufactured, and processed aggregates described as angular crushed stone, crushed rock, or crushed gravel and crushed stone/sand mixtures containing little or no fines with gradations selected to minimize migration of adjacent soils. Class IB aggregates must be compacted to 85% standard proctor density and tested to ensure proper compaction. Sieve requirements for Class IB aggregates for various PVC gravity sewer pipe nominal diameters are shown below.

2.2 Embedment for PVC gravity sewer pipe in ordinary trench conditions without high groundwater and without a hydraulic gradient when ASTM D2321 Class IB aggregate is not used, shall be ASTM D2321 Class IA open graded, clean, manufactured aggregates described as angular crushed stone, crushed rock or crushed gravel with large void content containing little or no fines. Class IA aggregates must be compacted. Sieve requirements for Class IA aggregates for various PVC gravity sewer pipe nominal diameters are shown below.

Nominal pipe diameter (inch)	Bedding material ASTM D2321 Class	Amounts Finer Than Each Laboratory Sieve (Square Openings) Mass Percent					
		Sieve Size					
		1 ½ inch (37.5 mm)	¾ inch (19mm)	½ inch (12.5mm)	3/8 inch (9.75mm)	No. 4 (4.75mm)	No. 200 (0.075 mm)
4	IA				100%	≤10%	≤5%
4	IB				100%	≤50%	≤5%
6	IA			100%		≤10%	≤5%
6	IB			100%		≤50%	≤5%
8 to 15	IA		100%			≤10%	≤5%
8 to 15	IB		100%			≤50%	≤5%
≥16	IA	100%				≤10%	≤5%
≥16	IB	100%				≤50%	≤5%

2.3 High strength embedment (steel reinforced concrete low cradle, steel reinforced concrete high cradle, steel reinforced concrete encasement, or steel reinforced concrete arch constructed to ASTM C12 (standards for Class A embedment) shall be used for problem soil conditions, near Karst features including caves and sink holes, for road crossings, for stream crossings, for water main/sewer main crossings, and for sewer main/stormwater conduit crossings.

2.4 PVC gravity sewer pipe laid at slopes equal to or greater than 20% and PVC gravity sewer pipe for which the combination of average inside diameter and slope result in a velocity greater than 15 feet per second (fps) when calculated using Kutter's Formula with an "n" value of 0.013 shall have mechanical restraints or poured concrete slope anchors with steel tie-down bars bearing against undisturbed earth at pipe bells

at a maximum spacing (center to center) of 36 feet (36') for slopes up to 35%, 24 feet (24') for slopes greater than 35% up to 50%, and 16 feet (16') for slopes greater than 50%. Slope anchors shall be constructed to ASTM F1668 Standard Guide for Construction Procedures for Buried Plastic Pipe. Slopes at which slope anchors (or mechanical restraints) are required for commonly used PVC gravity sewer pipes are shown below.

	Slope at which Slope Anchors are Required	Pipe Description & Nominal Diameter	Slope at which Slope Anchors are Required
ASTM D3034 SDR-35 6"	20.00%	ASTM F679 T-2 18"	>6.709%
ASTM D3034 SDR-35 8"	20.00%	ASTM F679 T-2 21"	>5.276%
ASTM D3034 SDR-35 10"	>16.12%	ASTM F679 T-2 24"	>4.451%
ASTM D3034 SDR-35 12"	>12.35%	ASTM F679 T-2 27"	>3.751%
ASTM D3034 SDR-35 15"	>9.098%	ASTM F679 T-2 30"	>3.169%
ASTM D2241 SDR-21 16"	>9.084%	ASTM F679 T-2 36"	>2.322%

2.5 Pipe Backfill: When granular stone backfill is required, the aggregate shall be identical to the pipe bedding material specified in paragraph 2.1.

3. EXECUTION

3.1 Pipe Bedding: Granular stone shall be placed in the trench and shaped so as to provide uniform support for the bottom quadrant of the pipe barrel. The bedding shall be not less than six (6) inches in thickness. Following the placement of the pipe, the trench shall be filled with granular stone bedding material to a minimum compacted depth of six (6) inches above the pipe bell. Bedding installation in trench shall be to the widths and depths as shown on the drawings.

3.2 Pipe Backfill: When granular stone backfill is required, it shall be of the specified graduation and shall be placed in the trench in maximum 24-inch thick layers and compacted to 80% of maximum density.

1. GENERAL

1.1 The work shall consist of furnishing and placing one or more courses of aggregate on a prepared sub-grade in accordance with these specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans.

2. MATERIALS

2.1 Granular stone base shall consist of MoDOT Type 1 or MoDOT Type 5 aggregate.

2.1.1 Type 1 aggregate shall be essentially limestone or dolomite. The aggregate shall not contain more than 15 percent deleterious rock and shale. Sand may be added only for the purpose of reducing the plasticity index of the fraction passing the No. 40 sieve in the finished product. Any sand, silt, and clay, and any deleterious rock and shall be uniformly distributed throughout the mass. The fraction passing the No. 40 sieve shall have a maximum plasticity index of six. The aggregates shall conform to the following gradation requirements:

Percentage by Weight Passing Each Sieve:

1 Inch Sieve	100%
½ Inch Sieve	60-90%
No. 4	35-60%
No. 40	10-35%

2.1.2 Type 5 aggregate shall consist of crushed stone or sand or gravel. The aggregate shall not contain more than 15 percent deleterious rock and shale. If crushed stone is used, sand may be added only for the purpose of reducing the plasticity index of the fraction passing the No. 40 sieve in the finished product. Any sand, silt, and clay, and any deleterious rock and shall be uniformly distributed throughout the mass. The fraction passing the No. 40 sieve shall have a maximum plasticity index of six. When sand and gravel aggregate are used, the fraction passing the No. 200 sieve shall be less than one half of that fraction passing the No. 30 sieve. The aggregates shall conform to the following gradation requirements:

Percentage by Weight Passing Each Sieve:

1 Inch Sieve	100%
½ Inch Sieve	60-90%
No. 4	35-60%
No. 30	10-35%
No. 200	0-15%

2.2 Material shall be delivered with sufficient moisture content to provide specified densities when compacted.

3. METHODS

3.1 Sub-grade: All work on that portion of the sub-grade on which the base is to be constructed shall be completed in accordance with the requirements of these specifications prior to the placing of any base material on that portion. Aggregate base shall not be placed on a frozen sub-grade.

3.2 Placing: The maximum compacted thickness of any one layer shall not exceed six (6) inches. When the specified compacted depth of the base course exceeds six (6) inches, the base shall be constructed in two or more layers of approximately equal thickness. The compacted depth of a single layer of the base course may be increased to eight (8) inches for shoulders and lightly traveled areas. After preliminary

compaction has been secured, finish compaction shall be carried to completion by means of self-propelled steel-wheeled rollers weighing not less than ten (10) tons. Shaping and compacting shall be carried on until a true, even, uniform base course of proper grade, cross section and density is obtained. Proper moisture content shall be maintained by wetting the surface or allowing it to dry as required during shaping and compacting operations. The use of excess water, resulting in run-off or in the formation of a slurry on the surface shall be avoided. The stone base shall be compacted to not less than ninety-five (95) percent of the maximum density at optimum moisture content.

3.3 Testing: The compacted base shall be tested for in place density by ASTM Method 2950, latest revision, at the rate of one (1) determination for each 1000 square yards of base surface, or as required by the Engineer.

3.4 Tolerance: The compacted base shall be brought to within a tolerance of ½" or less below design grade.

3.4.1 The compacted aggregate base thickness shall not be deficient in excess of ½ inch from the plan thickness. Thickness measurement shall be taken and determined for each 1500 square yards of base surface or as designated by the Engineer.

EXPLOSIVES 02225

1. GENERAL

1.1 Description: The work in this section consists of undertaking all phases of work which relate to explosives and blasting, including, but not necessarily limited to, receiving, handling, transporting, storing, distributing, priming, loading, firing, and disposal of explosives. The Contractor shall exercise the utmost care at all times not to endanger life or property.

1.2 Legal Requirements: The Contractor shall comply with all applicable Federal, State and local laws and regulations pertaining to the use, storage, and handling of explosives, and shall secure all required permits for their use. It is the intent of these specifications to comply with all such laws and regulations. In the event of inconsistencies between these specifications and the laws and regulations, the laws and regulations take precedence.

1.3 Personnel: One competent, experience person shall be specifically designated as being in charge of explosives at all times. The designated person shall be required to present certification to the Owner that he has successfully completed a course in the handling and use of explosives, given by an accredited institution such as the U.S. Bureau of Mines, DuPont or other explosive manufacturing company. He shall exercise careful supervision of all work related to the use, storage, and handling of explosives. Only an absolute minimum number of competent, experienced men, consistent with efficient operation, shall be permitted to handle explosives. Anyone exhibiting carelessness, incompetence, or inexperience shall be immediately excluded from further handling of explosives.

2. EXECUTION:

2.1 Protection of Site: The Contractor shall make proper use of blasting mats and other protective devices and shall adopt whatever additional precautions are deemed necessary to prevent damage to trees, shrubs and other landscape features, as well as to buildings, utilities, monuments, and other structures. All materials lifted by the blasting shall be confined within the limits of the trench or other excavation. Every reasonable effort shall be made to prevent injury to life and damage to the natural and the constructed surroundings. The Contractor shall take special precautions to prevent damage to surface structures, water supply mains, sewers, storm drains, other buried structures, and the basin dikes and basin floor. In the event that damage does occur, the Contractor shall be responsible for restoring the damaged property to a condition at least as good as before the damage was incurred or shall make a damage payment to the Owner equal to the cost of restoration.

2.2 General Requirements: The Contractor shall at all times be bound by the National Fire Protection Association Code No. 495, Code for the Manufacture, Transportation, Storage, and Use of Explosives and Blasting Agents (latest edition), except when this code is in conflict with existing Federal, State, and local laws and regulations. If there is conflict between the code and the laws and regulations, the most stringent requirement among them shall take precedence over the others. Safety rules, safeguards, and recommendations contained in the Manual of Accident Prevention in Construction (latest edition) of the Associated General Contractors of America shall supplement the above codes and existing laws and regulations. The Contractor shall give special attention to the following specific rules:

2.2.1 Magazines shall be located in accordance with the American Table of Distances for Storage of Explosives.

2.2.2 Magazines shall be bulletproof, fireproof, burglarproof, weather-resistant, and constructed with adequate screened ventilation and dry wooden floors. All nails exposed to the interior of magazines shall be well countersunk. Magazines shall be of such physical weight to preclude movement without heavy equipment (front end loader, etc.). Magazines shall not be provided with artificial heat nor lights, and shall be kept securely locked.

2.2.3 Detonators shall not be stored with other explosives but shall be stored in separate magazines.

2.2.4 Magazines and roads to them shall be clearly marked with appropriate caution and danger signs arranged to minimize the possibility of a bullet hitting the magazine should the signs be shot at by vandals.

2.2.5 The blast area shall be cleared of all unnecessary personnel and equipment prior to the delivery of any explosives to the site.

2.2.6 No more than one day's supply of explosives shall be kept at or near the work site and these explosives shall be kept in approved portable magazines.

2.2.7 Wooden tamping bars only shall be used for charging explosives into drill holes.

2.2.8 Electricity from light or power circuits shall not be used for firing shots unless the electrical connection to the circuit is made within an enclosed switch box which shall be kept securely locked with switch in open position.

2.2.9 A positive warning system shall be provided to give adequate warning in every direction immediately prior to the firing of explosives. The Contractor shall advise the Owner in advance of any detonating of charges. All access points to the blast area shall be guarded by responsible employees of the Contractor, stationed to halt personnel and vehicles a safe distance from the blast. Intercommunication between guards and the person firing the blast shall be maintained to determine that the danger area is positively clear prior to firing.

2.2.10 The Contractor shall also provide special signs or signals at all access points. Signs shall include a warning to turn off radio transmitters whenever electric detonators are used.

2.2.11 A properly sized "Hell Box" shall be used for electrically detonated shots. The use of equipment starting batteries is prohibited.

2.3 Removal of Materials: After a blast is fired, the Contractor shall cause the excavation to be thoroughly scaled and all loose and shattered rock or other loose material which may be dangerous to workmen, pipes, or structures shall be removed and the excavation made safe before proceeding with the work. The fact that the removal of loose or shattered rock or other loose material may enlarge the excavation beyond the required limits shall not relieve the Contractor from the necessity for making such removal. All excavated rock which cannot be removed similar to earth shall be kept separate from other excavated materials and shall not be mixed with other backfill material except as directed by the Owner.

2.4 Insurance: An insurance certificate covering blasting shall be furnished to the Owner by the Contractor or Subcontractors, before any blasting is performed.

2.5 Seismograph: If any question arises as to the effect of blasting on adjacent utilities, structures, etc., the Contractor shall be responsible for providing a seismograph to record the shock resulting from blasting activities.

COMPACTION CONTROL AND TESTING 02250

1. GENERAL

1.1 Description: The work of this section consists of furnishing all equipment, labor, materials, and incidentals to compact the various fill areas. Also, the Contractor shall provide the necessary on-site testing facilities and equipment.

2. MATERIALS

2.1 None.

3. EXECUTION

3.1 Maximum Density: The maximum density of the fill material shall be determined according to ASTM D698, "Standard Proctor Method". If more than one type of fill material is used, the maximum density for each type shall be determined. Determination of the maximum densities shall be the Contractor's responsibility. The Owner shall be provided with one copy of each maximum density test result, which shall include the maximum density and the optimum moisture content.

3.2 Compaction Operations: See Section 02221 - TRENCHING, BACKFILLING, AND COMPACTING.

3.3 Compaction Requirements: Compaction requirements for soils as controlled by methods of testing described herein are as follows:

3.3.1 Range A - In place compacted density of soil shall be equal to or greater than one hundred (100) percent of the maximum density at optimum moisture content.

3.3.2 Range B - In place compacted density shall be equal to or greater than ninety-five (95) percent of the maximum density at optimum moisture control.

3.3.3 Range C - In place compacted density shall be equal to or greater than eighty (80) percent of the maximum density at optimum moisture.

3.4 Density range for compaction shall be as stated on the drawings or as specified herein. Compaction requirements for granular stone or sand, as controlled by methods of testing described herein shall be to a density of not less than ninety-five (95) percent of the referenced density.

3.4.1 Range B Compaction shall be used for all compacted fill.

3.5 Compaction Operations:

3.5.1 Trenches & Adjacent to Structures - Compaction shall be achieved using manually operated mechanical tampers or towed and self-propelled drum and vibrator tampers.

3.5.2 Roadways & Fills: Compaction shall be achieved using rollers, vibrators, compactors, or mechanical tampers.

3.5.3 Variances: The use of water jetting or similar techniques of compaction is prohibited as the sole means for compaction.

3.6 Moisture Content & Control:

3.6.1 Content: The moisture content requirements as determined under the methods of testing described herein are as follows:

a. Range A Compaction: The moisture content of the soil at the time of compaction shall be uniform and shall be not higher than five (5) percentage points above the optimum nor lower than the optimum of the soil involved.

b. Range B Compaction: The moisture content of the soil at the time of compaction shall be uniform and shall not be lower than three (3) percentage points below the optimum moisture content of the soil involved.

c. Range C Compaction: The moisture content of the soil at the time of compaction shall not be lower than five (5) percentage points below the optimum moisture content of the soil involved.

d. Compaction of Granular Stone or Sand: The moisture content shall be not less than ten (10) percentage points below the optimum content at the time of compaction.

3.6.2 Control:

a. Water Application: The moisture content of the soil at the time of compaction shall be within the moisture range designated. When the natural moisture content of the embankment soil does not fall within the required moisture range, water shall be added or the material shall be aerated, whichever is needed to adjust the soil to the proper moisture content. Water may be transported or distributed from calibrated tank trucks or the water may be added to the soil in the borrow and cut areas before hauling, as long as the moisture content of the soil at the time of compaction is uniform and within the designated moisture range.

b. Testing: No water shall be added without the consent of the Resident Project Representative and without providing him adequate opportunity to measure the quantities used. The amount of water to be added shall be only that amount that will, as determined by the field moisture tests, provide a moisture content in the soil to be within the required range plus a reasonable amount to compensate for evaporation and other unavoidable losses. Satisfactory methods and sufficient equipment shall be used for the furnishing and handling of the water so there will be no undue loss due to evaporation. If water is added to cut areas or borrow pits, the surfaces of the areas or pits shall be maintained in such a manner that will prevent undue loss of moisture.

c. Visual Control: From other than the results of the moisture content test, the moisture content of the soil being compacted shall be considered as being too high to ensure compaction when after repeated rollings with the sheepsfoot roller, the roller continues to pick up excessive amounts of soil and refuses to "build up" so that the tamping feet eventually ride the compacted surface.

3.7 Compacting Equipment:

3.7.1 Sheepsfoot Rollers: Tamping or sheepsfoot rollers shall consist of metal rollers, drums, or shells, surmounted by metal studs with tamping feet projecting not less than six and one-half (6 ½) inches from the surface of the rollers, drum or shell. Tamping feet shall be spaced not less than six (6) inches, nor more than twelve (12) inches measured diagonally center to center; and the cross-section area of each tamper foot, measured perpendicularly to the axis of the stud, shall not be less than four (4) nor more than twelve (12) square inches. The weight of tamping rollers shall be such that, when fully loaded, the load on each tamper foot shall not be less than two hundred (200) pounds per square inch of cross-sectional area. The load per tamper foot will be determined by dividing the total weight of the roller (loaded) by the number of tamper feet in one (1) row parallel to the axis of the roller.

3.7.2 Pull-Type Steel Rollers: Pull-type steel rollers shall not have less than forty-eight (48) inches effective width of roll and shall be designed and constructed so that the weight per lineal inch of roll can be varied from two hundred (200) to at least three hundred (300) pounds.

3.7.3 Trench Rollers, Self-Propelling: The trench roller shall be an approved type and shall not weigh less than three hundred (300) pounds per inch of width.

3.7.4 Manually Operated Compactors: Equipment shall be in good mechanical condition and shall be capable of transmitting forceful vibrations or impacts to the various materials placed in construction.

4. SOIL TESTING

4.1 Testing Methods: Density tests, as prescribed in these specifications, will be made on the soil to be used in the construction of the project to determine a reference density, optimum moisture content, and the moisture range applicable to the soil required to attain specified compaction. The field density and actual moisture content of the compacted material shall also be determined as prescribed previously herein.

4.1.1 Reference Density: The density as determined by the specified compaction test shall be the density to which the field density is referred for comparison or percentage for each type of soil used in the work.

4.1.2 Optimum: The optimum shall be the moisture content corresponding to the reference density on the specified compaction test curve.

4.1.3 Moisture Range: The moisture range shall be the limits of moisture content of the soil with the optimum as a reference.

4.1.4 Field Density: The field density shall be the density of the compacted material determined by the field density test. If an in-field density test shows results below the minimum requirements, the lift or area in question shall be retested after additional compaction efforts are performed. If the original in-field density test results are more than two percentage points below minimum requirements, additional tests are required, and the area in question shall be scarified and re-compacted, if so designated by the Engineer. Additional testing and scarification shall be performed by the Contractor without any additional payment and shall be considered incidental to the completion of the project.

4.1.5 Moisture Content: The moisture content shall be the actual moisture content of the soil in the compacted embankment or fill at the time of compaction.

4.2 Scope of Tests:

4.2.1 Borrow Areas: All areas selected to supply backfill and area fill materials requiring a specified density shall have moisture-density relationships determined by ASTM Designation D-698, when the soil is initially excavated. In place density of compacted soil shall be tested in accordance with ASTM Designation D2167-63T or D2922, latest revision, to determine compliance with specifications. Specific testing locations will be determined by the Engineer.

4.2.2 Granular Stone & Sand: Granular stone and sand shall have moisture-density relationships determined by ASTM Designation D2049. In place density shall be determined by ASTM Designation D2167, ASTM D698, or D2922.

4.2.3 Compacted Soil Sub-Base Supporting Concrete, Steel, or Masonry Structures: Density shall be determined by a minimum of three samples and/or tests per structure, or two samples and/or tests per 1000 S.F. of area, for each two lifts of fill by ASTM Test Designation D2167-63T, or D2922.

4.2.4 Compacted Soil Sub-Base Supporting Rigid & Flexible Pavements & Crushed Stone Surfacing: Density shall be determined by a minimum of three samples and/or tests, or two samples and tests per 500 S.Y. of area, for each 6 inches of fill.

4.2.5 Compacted Granular Stone or Sand Supporting Concrete, Steel, Masonry Structures, Rigid And Flexible Pavements: Density shall be determined by a minimum of three samples and/or tests, or one sample and/or test per 100 S.Y. of area, whichever is greater.

5. MEASUREMENT AND PAYMENT

5.1 Measurement: Compaction of materials and testing thereof will not be measured separately for payment and will be considered incidental with the compacted fill, backfill, grading, and hauling requirements.

5.2 Payment: Compaction of materials and testing thereof will not be paid for separately and is considered to be included in the price for excavation, compacted fill, and backfill. Additional testing, if required by the Engineer for further verification of the embankment or fill compaction, will be considered incidental to the completion of the project and no additional payment will be made.

FINISH GRADING.....02260

1. GENERAL

1.1 Description: The work of this section consists of bringing to finish grade all areas on the site and furnishing all labor, materials, tools, and equipment necessary to complete this section.

2. EXECUTION

2.1 The Contractor shall grade the earth as indicated on the drawings.

2.2 In those areas noted on the drawings to receive seeding and mulching, the top six inches of all excavated areas shall consist of topsoil. Topsoil shall not be placed until the area has been shaped, trimmed, and smoothed, and, if the existing surface has become hardened or crusted, it shall be disked or raked so as to provide a bond with the layer of topsoil. The surface of the topsoil shall be free from lumps, clods, rocks, and shall conform to the lines and grades shown on the drawings.

2.3 Areas within the construction limits, regardless of whether or not they are to be seeded and mulched, shall be graded smooth and left with a neat and sightly appearance. The final grade around all structures shall be pitched to drain water away from the structures, and toward the roadside ditches, and natural drainageway. The finished grade shall be free of any and all projections which could interfere with mowing of the site.

PIPE BORING AND JACKING 02300

1. GENERAL

1.1 Description: The work defined by this section consists of furnishing all labor, equipment, tools, supervision, and materials for underground excavation. Materials excavated are unclassified and shall have no differentiation made for earth, rock, solid rock, sand, water, or other materials encountered.

2. MATERIALS

2.1 Carrier Pipe: Shall be of the size and type as noted on the plans, as specified in other sections of this document and as required by the permitting authority. The permitting authority shall have jurisdiction regarding type of materials required for the carrier pipe. The following list denotes applicable diameters for common pipe sizes and is based on published data. The contractor shall be responsible for insuring the accuracy of the largest diameter prior to construction.

Nominal Diameter	Material	Type of Joint	Largest O.D.
8"	PVC / SDR 35	Push-On	9.36"
8"	PVC / SDR 26	Push-On	9.69"
8"	D.I.	Push-On	11.16"
8"	D.I	M.J.	13.37"
10"	PVC / SDR 35	Push-On	11.70"
10"	PVC / SDR 36	Push-On	12.12"
10"	D.I.	Push-On	13.25"
10"	D.I.	M.J.	15.62"
12"	PVC / SDR 35	Push-On	13.94"
12"	PVC / SDR 26	Push-On	14.42"
12"	D.I.	Push-On	15.22"
12"	D.I.	M.J.	18.00"

2.2 Welded Steel Encasement Pipe: Shall be smooth wall, welded steel pipe with a minimum wall thickness as specified in American Petroleum Institute Code No. 1102. The provision of this code is listed as follows:

Nominal Diameter	Nominal Wall Thickness (Uncoated)
Under 12-3/4"	0.188" Min.
12-3/4"	0.282" Min.
14" and 16"	0.313" Min.
18"	0.344" Min.
20"	0.375" Min.
22"	0.407" Min.
24" and 26"	0.438" Min.
28"	0.469" Min.
30"	0.501" Min.
32" and 34"	0.563" Min.
36", 38" and 40"	0.626" Min.
42"	0.688" Min.

3. EXECUTION

1.1 Where designated on the plans, the Contractor shall carry out underground excavation for installation of pipe. Underground excavation shall be accomplished by tunneling, boring, or

jacking methods. Each method shall provide for removal of earth and rock coinciding with the installation of a primary liner or encasement pipe. Where jacking or tunneling is utilized, the annular space between the casing and earth shall be pressure grouted with sand cement grout. The casing pipe diameter shall be of sufficient diameter to comply with the requirements of the permitting authority. Typically the inside diameter of the casing shall be a minimum of 4" greater than the largest outsize diameter of the carrier pipe therefore for an 8" diameter, DR 14 PVC pipe with push-on joints would require a minimum casing diameter of 15.63" or 16" steel casing. The contractor shall verify all requirements of the permitting authority prior to commencing work.

1.2 The Contractor shall insure that traffic interruptions are minimized during the underground excavation operations. After the operation is completed, the Contractor shall slide the pipe into place. All pipe joints shall be completed outside of the tunnel and inspected by the Owner before the pipe is pushed into the tunnel. After the pipe is in place, the ends of the tunnel shall be sealed with sandbags prior to necessary backfilling. Carrier pipe shall be fitted with PVC spacers, or equivalent.

1.3 Any excavation required to provide equipment or personnel access to the tunnel work shall be considered incidental to the tunneling operation.

1.4 The Contractor shall make highway and railroad crossings where shown on the plans and shall obtain the permits and pay the necessary fees to make all crossings on the project. The Contractor shall comply with all requirements of the permitting authority and acquire necessary permits and bonds. Where the permitting authority (Highway Department, railroad company, etc.) requires encasement, tunneling, boring, timbering, shoring, bracing, rock excavation, cutting, and replacing pavement and base, and any other labor and material required. The Contractor shall receive no additional payment for any extra items involved.

SHORING 02400

1. GENERAL

1.1 Description: The work of this section shall consist of furnishing all equipment, labor, materials, tools, and incidentals necessary to provide for the safety of the employees and to protect the excavations for both structural and trenching and existing structures; and as required by the applicable federal and state laws and regulations.

2. METHODS

2.1 Responsibilities: The Contractor is solely and totally responsible for the design, installation, maintenance, and safety of any shoring and/or bracing that may be required.

2.2 Type of Shoring & Bracing: The type of shoring and bracing shall be that which is removable following the installation of the buried pipe or structure. No permanent type of shoring or sheeting shall be used which must remain within the limits of the excavation. The shoring or bracing shall be removed following the excavation, installation of the buried pipe or structures and installation of required backfill material.

SURFACE RESTORATION 02480

1. GENERAL

1.1 Description: The work of this section consists of furnishing all labor, materials, tools, and incidentals necessary to restore the surface of all areas affected by construction, including finish grading and landscaping as required herein, replacement of fences, stone-lined ditches, walls and embankments, and restoration of miscellaneous structures (mailboxes, street signs, etc.). The minimum requirement for surface restoration shall be Type B.

1.1.1 Type A Surface Restoration: Regardless of the site's previous condition, restoration consists of furnishing and placing topsoil (which may need to be hauled in), liming, seeding, mulching, laying netting as required, and otherwise preparing and establishing a uniformly grassed area as specified herein. Areas requiring Type A surface restoration shall be so designated on the drawings.

1.1.2 Type B Surface Restoration: Consists of furnishing and placing all the necessary materials to restore areas affected by construction to a condition equal to that which existed prior to construction.

1.1.3 Pavement Repair and Replacement shall conform to Section 02575 - ROADWAY SURFACE REPLACEMENT.

2. MATERIALS

2.1 Topsoil Stripped and Stored: Topsoil stripped, stored, and placed shall be fertile, friable, with liberal content of humus, and capable of sustaining vigorous plant growth.

2.2 Topsoil to be furnished: If the stripped topsoil is not adequate to complete the work, sufficient topsoil shall be furnished and shall be a natural, fertile, friable soil, possessing characteristics representative of productive soils in the vicinity. It shall be obtained from naturally well-drained areas. It shall not be excessively acid or alkaline (except for those planes requiring acid soil) nor contain toxic admixture of subsoil and shall be cleaned and reasonably free from clay lumps, stumps, roots, or similar substances, debris, or other objects which might be a hindrance to planting operations.

2.3 Lime: Lime shall be ground limestone containing not less than 85% of total carbonates and shall be ground to such a fineness that 50% will pass through a 100 mesh sieve and 90% will pass through a 20 mesh sieve. Coarser material will be acceptable, provided the specified rates of application are increased proportionately on the basis of quantities passing the 100 mesh sieve.

2.4 Fertilizer: Commercial fertilizer shall be formula 12-12-12, and shall conform to the applicable state fertilizer laws. It shall be uniform in composition, dry, and free flowing, and shall be delivered to the site in the original, unopened containers, each bearing the manufacturer's guaranteed analysis. Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be accepted.

2.5 Herbicide: Herbicide shall be a pre-emergence type for mixing with soil designed to eliminate noxious weeds without harming landscaped plants.

2.6 Lawn Materials: Grass seed shall be mixed and certified by the dealer and shall be a blend of K-31 fescue and Lespedeza, acceptable to the landowner. The seed shall be uniformly sown.

2.7 Water: The Contractor shall make, at his expense, whatever arrangements may be necessary to insure an adequate supply of water to meet the needs of this contract. He shall also furnish all necessary hose, equipment, attachments, and accessories for the adequate watering of plants as may be required to complete the work as specified.

2.8 Netting: Netting shall be a uniform, open, plain weave mesh of single jute yarn or 25 to 35 pound natural, unbleached kraft paper. Minimum width of netting fabric shall be 42 inches. Jute netting shall have 76 warp ends per 48 inch width and 41 weft ends per yard, minimum. Kraft paper netting shall have 5.5 warp yarns by 3.5 filling yarns per inch. Staples for anchoring netting shall be No. 11 gauge steel wire, six (6) inches long.

2.9 Mulch: Vegetative mulch shall be the shredded cereal straw form stalks of oats, rye, wheat, or barley. The straw shall be free of prohibited weed seeds as stated in the State Seed Law; shall be relatively free of all other noxious and undesirable seeds; and shall be clean, bright, and dry enough to spread properly. A binder emulsion shall be applied to prevent straw from blowing.

3. EXECUTION

3.1 All areas within the limits of fine grading not required to be developed otherwise shall be planted with grass.

3.2 Soils Test: The Contractor shall, at his own expense, contact the County Extension Agent and secure a soil test of the topsoil. If recommended by this test, the topsoil shall be limed in quantity recommended by the Extension Agent. (Generally a soil pH of 6.0 to 6.5 is desirable.) Three copies of the soil test shall be sent to the Owner along with recommendations on lime use. Estimates of lime requirements are as follows:

POUNDS OF GROUND LIMESTONE PER 1,000 SQUARE FEET

pH	Light Sandy Soil-Pounds	Medium Sandy Soil-Pounds	Loam & Silty Loam-Pounds	Clay Loam Pounds
4.0	90	120	172	217
4.5	82	112	157	202
5.0	67	90	127	150
5.5	52	67	97	120
6.0	None	None	None	None

3.3 Time of Planting for Lawns: The Contractor shall coordinate the work so that lawn areas will be topsoiled and graded to meet the planting schedule as follows:

3.3.1 Preferred Time of Planting:February 1 to April 20.

3.3.2 Alternative time of Planting: September 1 to October 30. For this time of planting, the Contractor shall keep the lawn well watered through the summer, or until the project is accepted by the Owner.

3.4 The Owner is aware that in some cases, it would create a hardship to maintain the above schedule. If the Contractor wishes to make recommendations on other times when seeding could be done, the Owner will consider these recommendations. However, methods or time of planting shall be agreed to, in writing, before commencing this portion of the work or the above schedule shall be followed.

3.5 Preparation of Topsoil: The topsoil shall be graded and uniformly compacted according to Section 02260 - FINISH GRADING.

3.6 Sulphur: If the addition of sulphur is necessary, it shall be applied at a rate of two pounds per 1000 square feet.

3.7 Applying Fertilizer: Commercial fertilizer shall be applied at the rate of 20 pounds per 1,000 square feet to the lawn areas being prepared for planting. Fertilizer may be applied with seed, however, application after sprouting of the lawn seed is preferred.

3.8 Sowing of Seed: Immediately before any seed is to be sown, the ground shall be scarified as necessary and shall be raked until the surface is smooth, friable, and of uniformly fine texture. Lawn areas shall be seeded evenly at the rate of 100 pounds per acre, lightly raked, and watered with a fine spray. The method of seeding may be varied at the discretion of the Contractor on his own responsibility to establish a smooth, uniformly grassed lawn.

3.9 Mulching: Within 24 hours after seeding, mulch with binder emulsion shall be spread evenly over the entire area at the rate of 2 1/2 tons per acre.

3.10 Optional Establishment of Lawns: At the option of the Contractor, sod may be used for establishing all or part of grass lawn areas. Sod on slopes shall be held in place by wooden pins about one inch square and six inches long driven through the sod into the soil until they are flush with the top of the sod. Before any sod is laid, all soft spots and inequalities in ground shall be corrected. Fertilizer spread shall be raked in. sod shall be laid so that no voids occur and shall be tamped or rolled. The complete sodded surface shall be true to finish grade, even, and firm at all points. Sod shall be placed so that the surface of the compacted sod will be slightly below the surrounding surface soil. All soils tests and pH adjustment specified previously shall be undertaken prior to sodding.

3.11 Clean-up: Any soil, manure, peat or similar material which has been brought onto paved areas by hauling operations, or otherwise, shall be removed promptly, keeping these areas clean at all times. Upon completion of the planting, all excess soil, stones, and debris which has not previously been cleaned up shall be removed from the site or disposed of. All lawns and planting areas shall be prepared for final inspection.

3.12 Maintenance: Maintenance shall begin immediately after planting and shall continue in accordance with the following requirements:

3.12.1 Repairs: Repairs to lawns or replacement of plants necessary during the maintenance period due to removal, vandalism, or acts of neglect on the part of others may be done on request by the Owner and will be done at the expense of the Owner.

3.12.2 Maintenance: Lawns shall be protected and maintained by the Contractor by water, mowing, and replanting as necessary for at least thirty (30) days and as much longer as is necessary to establish a uniform stand of the specified grasses, and until acceptance by the Owner.

3.13 Inspection: Inspections of the work to determine completion of contract work exclusive of possible replacement, will be made by the Owner at the conclusion of the maintenance period upon written notice requesting such inspection submitted by the Contractor at least 10 days prior to the anticipated date. The condition of lawns will be noted and determination made by the Owner as to whether maintenance shall continue in any part. After inspection, the Contractor will be notified in writing by the Owner of acceptance of seeding work exclusive of the possible replacement.

3.14 Guaranty and Replacement: Lawns and planting shall be guaranteed for a maximum of one year after the conclusion of the maintenance period, or for the duration of one full growing season, after planting, whichever is longer, and shall be alive, and in satisfactory growth at the end of the guaranty period, subject to normal care as recommended by this Contractor after acceptance of the work. At the end of the guaranty period, inspection will be made by the Owner upon written notice requesting such inspection submitted under this contract that is dead or not in satisfactory growth, as determined by the Owner, shall be removed from the site. These shall be replaced as soon as conditions permit, but during the normal planting season.

ASPHALTIC CONCRETE PAVING 02513

1. GENERAL

1.1 Description: The work of this section consists of furnishing all labor, materials, equipment, and tools for construction of asphaltic concrete paving for streets and drives. The asphaltic concrete shall be placed in one or more courses on a prepared stone base or underlying course in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans, or as designated by the Engineer.

2. MATERIALS

2.1 Base Course: Shall conform to specification Section 02232 - GRANULAR STONE BASE.

2.2 Prime Coat: The prime coat shall be medium-curing, cut back (MC-30) asphalt and shall conform to AASHTO M-82.

2.3 Tack Coat: The tack coat shall be an emulsified asphalt (SS-1) and shall conform to ASTM 977.

2.4 Surface Course: The asphaltic concrete surface course shall comply with MoDOT Type BP-2 Section 401 and associated MoDOT specifications.

2.5 Binder Course: The asphaltic concrete binder course, if job specified, shall comply with MoDOT, Section 301, and shall consist of a mineral aggregate compound of crushed stone and/or crushed gravel, sand gravel, sand, mineral filler, if needed, and asphaltic cement in such proportions that the composition of the finished mix is within the following range:

	% Min.	% Max.
Passing 1-inch sieve	100	--
Passing ½-inch sieve	60	90
Passing No. 4 siiev	35	65
Passing No. 8 sieve	25	50
Passing No. 30 sieve	15	35
Passing No. 200 sieve	5	12
Asphalt Cement	3.5	6

2.6 Asphalt Cement: Shall be AC-10, AC-20, AC-30 asphalt cement, or approved by Engineer homogenous and free of water and shall not, in heating, foam below 232 degrees centigrade. Asphalt cement shall be prepared by refining crude petroleum by suitable methods, and shall conform to the requirements of Section 1015 of the Missouri Standard Specifications for Highway Construction.

2.7 Samples: At least 15 days prior to preparing any of the mixture on the project, the contractor shall obtain in the presence of the Engineer, representative samples of the asphalt cement and mineral aggregate for tests. The samples of materials shall be of the size specified by the Engineer and the contractor shall submit the samples to a qualified laboratory for testing. The contractor shall also submit for the Engineer's approval, a job-mix formula for each mixture to be supplied for the project. No mixture will be accepted for use until the job-mix formula for the project is approved by the Engineer.

3. EXECUTION

3.1 Existing Roadway: The existing roadway surfacing shall be removed to the depth cross sections shown on the plans.

3.2 Sub-grade Preparation: Shall be as described in specifications Section 02200 - EARTHWORK.

3.3 Base Course:

3.3.1 Contractor shall furnish, place, and compact a thickness of base course as specified on the plans of crusher run limestone on a prepared sub-grade, as described in Section 02232 - GRANULAR STONE BASE.

3.3.2 In no case shall the Contractor be permitted to place the granular base or manipulate it on muddy or frozen sub-grade. Any mixture containing frost or frozen particles shall not be placed on the sub-grade, or compacted.

3.3.3 The granular base shall be handles in such manner as to avoid undue segregation. If segregation occurs or if the mixture becomes contaminated, such segregation or contaminated material shall be removed and replaced with material of suitable quality and gradation. Segregated or contaminated materials ordered removed by the Engineer shall be replaced at the sole expense of the Contractor.

3.3.4 Preliminary compaction shall be performed by means of pneumatic-tired rollers. After preliminary compaction has been secured, finish compaction shall be carried to completion by means of self-propelled steel-wheeled rollers weighing not less than ten tons. Shaping and compacting shall be carried on until a true, even, uniform base course of proper grade, cross-section, and density is obtained. Proper moisture content shall be maintained by wetting the surface or allowing it to dry as required during shaping and compacting operations. The use of excess of water resulting in run-off or in the formation of a slurry on the surface shall be avoided. The stone base shall be compacted to not less than 95 percent of the maximum density of optimum moisture content as determined by Mod AASHTO T-99.

3.4 Prime Coat: The prime coat shall be place only on a dry or slightly damp, clean base free from loose or foreign material when atmospheric temperature is above 50°F. The rate of application shall be from 0.2 to 0.5 gallons per square yard, depending upon the surface texture. Temperature of the prime coat at the time of application shall not be less than 100°F, or more than 180°F. Any prime coat overspray on adjacent concrete surfaces shall be removed to the Owner's satisfaction.

The prime coat shall be allowed to cure a minimum of 24 hours before application of the surface course.

3.5 Tack Coat: The tack coat shall be placed on an existing asphaltic surface which is free of all dust, loose material, grease, or other foreign materials when atmospheric temperature is above 40°F. The asphalt emulsion shall be applied uniformly with a pressure distributor at a rate of application from 0.02 to 0.10 gallons per square yard. Water may be added to the asphalt emulsion and mixed therewith in such proportion that the resulting mixture will not contain more than 50 percent of added water. The application of the resulting mixture shall be such that the original emulsion will be spread at the specified rate. Temperature of the tack coat at the time of application shall not be less than 75°F or more than 130°F.

3.5.1 The tack coat shall be allowed to properly cure and the tacked surface shall be cleaned of all dirt and surplus sand before the next course is placed.

3.5.2 The tack coat shall be applied in such a manner as to cause the least inconvenience to traffic and to permit one-way traffic without pickup or tracking of the asphalt emulsion.

3.6 Surface and Bituminous Base Course: The asphalt concrete surface course shall be a hot plant-mix of specified thickness suitable placed and compacted, and shall be placed in layers not exceeding three inches in compacted thickness. The asphaltic concrete shall be delivered to the work area in dump trucks properly lubricated to prevent sticking. The asphaltic concrete shall be covered during transit, and shall arrive at the job site at not less than 275°F. Placing of asphaltic concrete shall be as follows:

3.6.1 The asphaltic concrete shall not be placed, when either the air temperature or temperature of the surface on which the mixture is to be placed is below 50°F for the surface course or 40°F for the bituminous base course, or on any wet or frozen surface, or when weather conditions prevent the proper handling or finishing of the mixture, or when authorized by the Engineer.

3.6.2 The asphalt concrete surface shall be compacted while the mixture is hot with power roller equipment as specified. Rolling shall continue until a uniform, even textured surface of the thickness specified is produced. Rolling shall begin at the outer edge and continue toward the center. Each pass shall overlap the preceding one by at least one-half of the rear roller width. Delays in rolling freshly spread mixture will not be tolerated. Traffic shall not be permitted on the finished pavement until it has cooled to atmospheric temperature. Final rolling shall be done with either a two or three-wheel tandem-type roller weighing not less than 10 tons.

3.6.3 Around areas not accessible to power rollers, compaction shall be secured by hand tamping, and all joints must be effectively sealed.

3.6.4 The finished surface shall be rolled until it is free from waves and irregularities. All surplus material shall be removed prior to final acceptance.

3.6.5 If the asphaltic concrete construction consists of more than a single layer, each layer shall be compacted as specified and allowed to cool to the ambient temperature before the next layer is placed.

3.6.6 The contractor shall provide a leveling course at areas and at a thickness necessary to obtain the elevation and cross sections as shown on the plans, prior to placing the surface course. The areas of existing asphaltic pavement which require an overlay of asphaltic concrete shall be as specified on the plans. The finished surface course as placed shall be performed in such a manner as to provide the smoothest possible riding surface.

3.7 Equipment: All equipment, tools, and machines used in the performance of the work shall be subject to the approval of the Engineer and shall be maintained in satisfactory working condition at all times.

3.7.1 The Asphalt Distributor: Shall be a machine manufactured for the specific purpose of applying heated asphaltic materials by pressure spray application. The Distributor shall be designed to permit the application of the heated asphalt material in a uniform spray without atomization and at the rate, temperature, and pressure specified by the Asphalt Institute. The Distributor shall be equipped for circulation and agitation of the bituminous material during the heating process.

3.7.2 The Power Roller: Shall be a self-propelled type weighing at least eight tons and shall be suitable for rolling bituminous pavements. A five ton roller may be used around radii and driveways where rolling with an eight ton roller is not feasible. The roller shall be equipped with adjustable wheel scrapers and a sprinkling system which will uniformly wet the wheels to prevent adherence of bituminous material to them. Rubber tired rollers may be used after initial rolling with eight ton roller.

3.7.3 Mechanical Spreaders and Finishers: Shall be adjustable and capable of spreading upon the prepared surface a tamped, screeded and finished wearing surface of asphalt concrete of the specified thickness.

3.7.4 Broom Drag and Power Brooms: Shall be of the type suitable for effectively cleaning the surface to be treated.

3.7.5 Automatic Screed Control: The use of automatic screed control devices will be required except for paving small irregular areas, shoulders, entrances, and side road connections. The screed of the mechanical spreading and finishing machine shall be regulated by an automatically

controlled grade leveling and slope control device approved by the Engineer. The device shall be of a standard commercial quality adapted to the type of paver used and shall provide control for producing a uniform surface to the established grade, and a cross slope conforming to the requirements of the typical section.

The initial pass of the paver, when placing the first continuous layer, shall be made with the sensor following a traveling reference plane not less than 30 feet in length that is an integral part of the paver. An established grade reference is required by the contract, the contractor will establish the grade and will furnish variable thickness values at intervals along the center line of the roadbed for the use in setting a grade reference. Regardless of the method used for placing the first continuous layer, all other layers shall be placed by use of a shoe-type sensor or indicator, the traveling reference plane, or by additional use of the established grade reference.

3.8 Compaction and Testing:

3.8.1 After final rolling, the finished course shall at no point have a density less than ninety-five (95%) percent of the laboratory compacted density. Field determination of the density shall be the responsibility of the Contractor and considered incidental to the paving operations. Contractor shall provide access to the Engineer and his representatives for any and all testing of asphaltic concrete paving.

3.8.2 Testing Pavement: The finished courses shall have the minimum thickness shown on the plans. Tests will be made to insure that each course is being constructed of proper thickness, composition, and density. The Contractor shall cut samples from any layer of the compacted mixture at locations designated by the Engineer and shall deliver them to the testing laboratory in good conditions. Samples may be obtained by wither sawing with a power saw or by drilling 4-inch diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the Engineer, but not larger than 12 inches square.

3.8.3 Density Samples: Each sample for laboratory density determination shall consist of four cores. All samples, whether sawed or cored, shall consist of an undisturbed portion of the compacted mixture removed for the full depth of the layer or course to be tested.

3.8.4 Thickness Samples: Each sample taken for course thickness shall consist of one 4-inch diameter core taken for the full depth of the course. Each sample taken for total compacted thickness shall consist of one 4-inch diameter core taken for the full depth of bituminous construction. Total thickness samples shall be obtained after all bituminous construction is completed on the project and shall be taken at locations designated by the Engineer.

3.8.5 Surface Restoration: The surface from which samples have been taken shall be restored by the Contractor with the mixture then being produced not later than the next day of plant operation, if construction is still in progress. If bituminous construction has been completed, the surface from which samples have been taken shall be restored within 48 hours with hot mix asphalt acceptable to the Engineer.

3.8.6 Grade and Surface Smoothness Requirements: The finished surface of the bituminous courses shall conform to the grade lines and elevations shown on the plans. The grade and crown slopes shall not deviate more than 0.05 feet from the plan grades. The surface shall not vary more than ¼ inch when a 12 foot straightedge is laid on the surface parallel with the centerline of the paved area or transverse from the crown to pavement edge.

3.8.7 Quality of Samples & Tests: The Contractor shall provide as an obligation incidental to the performance of the contract, the following minimum quantity of samples and tests.

a. From the paving spreader, not less than one (1) composite sample for each 1000 square yards or less of surfacing to be constructed. This sample shall be tested for asphaltic cement content, aggregation gradation and content, and attainable density.

b. From the compacted surfacing, not less than one (1) core sample for each 2500 square yards of asphalt surfacing applicable for thickness determination and laboratory tests. On the compacted surface, not less than one (1) in place density test for each 300 square yards of asphalt surfacing applied.

3.8.8 Test Designation:

a. Asphaltic Cement Content: Compacted and uncompacted samples shall be tested by procedures established by ASTM D2172, latest revision, to determine asphalt cement content.

b. Aggregate Gradation: Coarse and fine aggregate from asphaltic concrete samples shall be tested for gradation by ASTM Test Method C136, latest revision. Mineral filler content shall be determined by Test Method ASTM C117, latest revision.

c. Density: In place density shall be determined by ASTM Test Method D2950. Reference density shall be determined by ASTM D1188, or ASTM D2726 procedures and ASTM procedures D2041.

4. REMEDY AND CORRECTION OF DEFICIENCY

4.1 The Contractor shall provide, at not cost to the Owner, remedy and correction of deficiencies in the asphaltic surfacing, in the following specified form and procedures:

4.1.1 Deficiency in Asphalt Cement: Should test on uncompacted samples or core samples indicate the asphalt content is below the specified amount, the Contractor shall provide additional asphaltic concrete overlays to the entire surfacing area for which the tests indicated an asphalt cement deficiency. One (1) inch of compacted asphaltic concrete overlay shall be added for each one-tenth percent the asphalt cement content falls below specified minimum. The percent deficiency shall be determined from the average of the percent asphalt cement content from five samples.

4.1.2 Deficiency in In-Place Density: Should tests on core samples or in-place density tests indicate density of the asphaltic concrete to be below the specified minimum density, the basis of payment for deficiency in in-place densities for any one day's run of asphaltic concrete shall be determined as follows:

Average Density (%) as determined from 4 in-place density tests or total tests performed during each day's run of asphalt	Percent of Payment
95-100	100.0
94.9	100.0
94.8	99.9
94.7	99.8
94.6	99.6
94.5	99.4
94.4	99.1
94.3	98.7
94.2	98.3
94.1	97.8
94.0	97.3
93.9	96.3

93.8	94.1
93.7	92.2
93.6	90.3
93.5	87.9
93.4	85.7
93.3	83.3
93.2	80.6
93.1	78.0
93.0	75.0
below 93.0	Reject

4.1.3 Deficiency in Surface Limit: Surface finish shall be provided such that surface water drains to ditches and guttering. Depressions in the surfacing, which are exhibited by ponding of water, shall be remedied by the addition of an overlay of asphaltic concrete to eliminate the depression.

4.1.4 Deficiency in course and total thickness: Should tests on core samples indicate the thickness is less than the design thickness, the Contractor shall provide additional asphaltic concrete overlay to the entire surfacing area for which the tests indicated a thickness deficiency. One inch minimum of compacted asphaltic concrete overlay shall be added to those deficient areas. The areas which are found to be deficient shall first be cold milled ½ inch minimum over the entire deficient area, then overlaid with a thickness sufficient to bring the area up to the design thickness and grade. The deficient area shall be determined in accordance with 3.6.7.2 and/or from core samples taken at a minimum distance of 200 feet between cores, or as approved by the Engineer.

DEWATERING 02530

1. GENERAL

1.1 Description: The work of this section consists of completing all dewatering work necessary for the initiation and prosecution of elements of work specified elsewhere.

2. EXECUTION

2.1 Workmanship: Maintain all excavations and trenches free from water at all times while construction is in progress using pump. Prevent surface runoff water from collecting in excavations or trenches or running down the faces of excavated cut or fill slopes, causing sloughing or caving, ponding in excavated areas or saturating the soils below foundations of structures by adjusting grades to provide temporary drainage facilities. The Contractor shall furnish and operate sufficient pumps and appliances, and provide all materials, labor, etc., required to prevent interference with any work by water, ice or snow. Damage of any kind resulting from insufficient pumping facilities or similar lack of proper conduct of the work shall be made good by the Contractor at his own expense. No structure or pipes shall be laid in water, and water shall not be allowed to run into or over any concrete work or pipe, or into or through any pipe.

ROADWAY SURFACE AND SIDEWALK REPLACEMENT 02575

1. GENERAL

1.1 Description: The work of this section shall consist of furnishing all labor, materials, tools, equipment, and incidentals necessary to replace all roadway surfaces and sidewalks removed during utility construction. This section shall include, but not be limited to, vehicular and pedestrian pavements, and surfaces of stone, gravel, asphalt, and Portland cement concrete, in addition to parking areas.

2. MATERIALS

2.1 Portland Cement Concrete: Shall conform to Section 03300 - CAST-IN-PLACE CONCRETE.

2.2 Hot-Mix Asphaltic Concrete: Shall conform to Section 02513 – ASPHALTIC CONCRETE PAVING.

2.3 Crushed Stone: Shall conform to Type 1 aggregate as specified in Section 02223 – CRUSHED STONE BASE.

2.4 Chip and Seal Pavement Repair:

2.4.1 Aggregate: For aggregate seal asphalt paving, the aggregate shall consist of a combination of crushed stone and/or crushed gravel, well-graded within the following limits:

Sieve Size	Percent Paving by Weight
1/2"	90-100%
3/8"	48-80%
#4	0-15%
#6	0-5%

2.4.2 Liquid Asphalt: The liquid asphalt shall be grade CRS-2. Should the Contractor desire, (because of climatic conditions or otherwise) he may request a change in the liquid asphalt grade. No change shall be made until the Contractor receives written approval from the Owner.

3. EXECUTION

3.1 General: Existing paving shall be cut vertically and horizontally to straight lines. The trench shall be backfilled with granular stone bedding or controlled backfill material compacted to Range B compaction requirements (see Section 02250 - COMPACTION CONTROL AND TESTING) to within eight inches of the final roadway surface. The top eight-inches shall be backfilled with crushed stone base compacted level with the existing riding surface of the roadway. This level shall be maintained by the Contractor until all secondary settling has occurred. Any crushed stone required to maintain the trenches in a suitable condition for traffic during this period shall be furnished at the Contractor's expense. When the trench has been properly backfilled and has settled sufficiently to permit final repairs, roadway surfacing shall be applied according to this specification. At the time of final repairs, the Contractor shall remove sufficient material to allow placement of roadway surfacing to the thicknesses specified as follows.

3.2 Roadway Surface Replacement:

3.2.1 Portland Cement Concrete: Edges of existing pavement at the trench shall be trimmed vertically to produce a neat even edge. A minimum 8-inch thick concrete slab shall be placed to match the elevation of the existing pavement, as shown on the drawings.

3.2.2 Hot-Mix Asphaltic Concrete: Edges of existing pavement at the trench shall be trimmed vertically to produce a neat, even edge. A minimum of 4-inches of hot-mix asphaltic shall be placed in two lifts to match the elevation of the existing pavement, as shown on the drawings.

a. The surface to receive the asphalt concrete shall be cleaned of all loose material, dust, and foreign matter prior to the application. The primer or tack coat, as required, shall be applied upon a dry surface only at a rate of 0.15 gallons per square yard. Forms may be of any material or design provided they secure the designed grade control. It shall be the responsibility of the Contractor to set and maintain necessary grade staked and forms, and execute the work to the lines, grades, cross sections, and dimensions shown on the plans.

b. After spreading, the mixture shall be thoroughly and uniformly compressed by a three-wheel or tandem power-driven roller or rollers, weighing not less than 200 pounds per inch of tread width, as soon after being spread as it will bear the roller without undue displacement. Delays in rolling freshly spread mixture will not be tolerated. Rolling shall start longitudinally at the sides and proceed toward the center of the pavement overlapping on successive trips by at least one-half the width of a read wheel. Alternate trips of the roller shall be of slightly different lengths.

c. After final compression, the finished course shall at not point have a density less than ninety-five (95) percent of the laboratory compacted density. At least two (2) in-place density samples shall be taken and tested.

d. No traffic shall be permitted on the finished pavement until it has cooled to atmospheric temperature.

3.2.3 Chip and Seal Pavement Repair: For this type repair, a double layer of chip and seal resurfacing over the entire roadway width will be utilized.

a. The existing roadway shall be bladed to eliminate minor depressions and humps. Following the blading operation, the surface shall be thoroughly cleaned and swept to remove all mud, matted earth, dust, and other foreign material.

b. A prime coat of liquid asphalt shall be applied at the rate of 0.30 gallons per square yard at a minimum temperature of 120 degrees Fahrenheit for asphalt grade CRS-2. On the primed base, a course of aggregate shall be spread at the rate of twenty-five (25) pounds per square yard. This stone shall be roller compacted from the sides to center with a steel wheeled roller weighing a minimum of five tons.

c. Immediately following the compaction of the first course of asphalt and aggregate, a second course, identical to the first, shall be applied. The finish surface shall be swept to remove any loose stones.

d. No traffic shall be allowed on the finished surface until it has cooled to atmospheric temperature.

3.2.4 Crushed Stone: Trenches along or across unpaved roadways, including country roads, and city streets, as well as on dirt, or gravel shoulders of paved streets, roads, or highways, shall be backfilled in compliance with these specifications. The trench shall be backfilled to a level with the existing riding surface of the roadway. When the trench has been properly backfilled and has settled sufficiently to permit final repairs, the backfill shall be removed as necessary for crushed stone surfacing. The crushed stone shall be rolled and thoroughly compacted in layers to a minimum finished thickness of six-inches.

3.2.5 Sidewalk Replacement: The existing concrete sidewalk and base material shall be removed for a distance equal to the trench width plus two feet as shown on the drawings. The trench shall be backfilled to a height that will allow the placement of four inches of crushed stone and a four-inch thick concrete walk above. The elevation of the top of the new sidewalk section shall match that of the existing walk.

1. GENERAL

1.1 Description: The work of this section shall consist of furnishing, hauling, and placing all precast concrete manholes shown on the drawings and as required for sewer line construction.

1.2 Precast concrete manholes shall be of the type, size, and configuration shown on the drawings, and all manholes shall be provided by one sole manufacturer.

2. MATERIALS

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

2.2 Concrete Reinforcement: Shall be as specified in Section 03200 - CONCRETE REINFORCEMENT.

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

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

2.5 Water: Mixing water shall be clean and potable.

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

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

2.8 Joint Wrap: Shall be a stretchable, self-shrinking, intra-curing halogenated based rubber meeting the requirements of ASTM C923 and shall have a minimum thickness of 30 mils.

2.8.1 Adhesive: The joint wrap shall be secured with a cross-linked reinforced butyl adhesive. The adhesive shall be a non-hardening sealant with a minimum thickness of 30 mils.

2.9 Grout: Grout shall be a pre-mixed, packaged, non-ferrous, aggregate non-shrink grout.

2.10 Manhole Frame and Cover: Frame and cover shall be made of clean, even grain, tough gray cast iron. The casting shall be smooth, true to pattern, and free from projections, sand holes, warp and other defects which would interfere with the use of, or impair the serviceability of the casting. The iron used for these castings shall conform to ASTM A48, latest revision, for Class 35B gray iron.

2.10.1 Frame and cover shall have machined horizontal bearing surfaces and shall be Neenah Foundry R-1769-A or approved equal. Minimum clear opening of the access shall be 22 inches.

3. EXECUTION

3.1 Fabrication and Manufacturing: Precast reinforced concrete manholes shall be manufactured to requirements of ASTM C478, latest revision and shall be of the type, size, and configuration shown on the drawings. Manhole tops shall be of the eccentric type. The minimum allowable wall thickness shall be determined by the manhole depth as below:

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

3.1.1 Minimum internal diameter of any manhole section shall be 4 feet.

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

3.3 Construction:

3.3.1 Manhole Base: The manhole base shall be of either cast-in-place reinforced concrete or a precast concrete unit with the precast unit being the preferred method on all new installations.

a. Precast manhole bases shall consist of either a precast unit with integral invert or a precast base with field constructed invert. Either type of precast unit shall be set on a minimum of 6" of compacted crushed stone. The unit shall be set plumb and to the elevation as shown on the plans.

b. Cast-in-place concrete base shall be constructed of 3,500 min. psi concrete, 4-inch max. slump concrete with #4 steel reinforcing bars at 12-inch on center each way. The bottom section of the precast unit shall be set into the base a minimum of 12 inches. The base shall extend not less than 6 inches beyond the outside manhole wall.

c. Bench: A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than a one-half inch per foot (0.5 in/ft). No pipe shall discharge onto the surface of the bench.

3.3.2 Precast riser sections shall be set plumb and oriented with manhole steps and access opening to match the detailed drawings designations. Each section of the precast concrete manhole shall be set in a pre-molded mastic material or a rubber gasket. Joint wrap shall also be applied to the exterior of manhole at each joint so as to produce an absolutely watertight joint under full hydrostatic head conditions. The joint wrap shall be installed per the manufacturer's requirements and recommendations.

3.3.3 Openings for sewer pipe in manhole sections shall be formed at the factory, either cast-in-place gasket or cut out opening. The minimum opening for cutouts shall be equal to outside diameter of pipe plus four inches and maximum opening shall be equal to outside diameter of pipe plus six inches.

3.3.4 Flexible watertight cast-in-place gaskets shall be used, and shall be A-LOK or approved equal.

3.3.5 Invert channels shall be smooth and semi-circular in shape conforming to the inside of the adjacent pipe line sections with change in flow direction made by a smooth curve of as large a radius as the manhole size will permit, and changes in the size and grade of the channels being made gradually and evenly. Manhole floor shall rise a minimum of 1 inch per foot from side of channel to wall.

3.3.6 All frames and covers shall be set true to line and to correct elevation upon a mastic gasket. Frames and covers shall have true common bearing surfaces, such that the covers will seat firmly without rocking or shifting. In areas prone to flooding or surcharging manhole frames shall be attached to manholes with anchor bolts.

3.3.7 Manhole Drop: In manholes where the difference in the inverts of the inlet and outlet pipes is 2 feet or more an outside drop shall be constructed as shown on the standard construction details. If precast manholes are utilized, the drop connections shall not enter the manhole at a joint.

3.3.8 Inlet and outlet pipes shall extend through the walls of the structures a sufficient distance beyond the outside surface to allow for connections, and shall extend two inches beyond the inside surface of the wall. The new manhole shall be cleaned of silt, debris, or other foreign matter prior to acceptance.

3.3.9 All lifting holes shall be thoroughly wetted and completely filled with non-shrinking grout to form a watertight seal.

3.4 New Manhole Over an Existing Line: Manholes to be located over an existing sewer line shall be built so that all of the manhole inverts will be smooth and continuous after the sewer tile is broken open.

3.5 Connections to Existing Manholes: Existing manholes used for connecting new sewer lines to the existing sewerage system shall have the new sewer line connected by core boring a hole in the side of the existing manhole at the new plan flowline elevation. The bore hole shall be of sufficient diameter to allow for the insertion of an A-lok gasket or equal such to provide a flexible watertight connection. The new sewer pipe shall then be inserted into the gasket and invert grouted to provide a continuous, uninterrupted flow of existing and new sewage.

1. GENERAL

1.1 Description: The work in this section consists of furnishing, hauling, placing, and backfilling as necessary the ductile iron pipe, fittings, and fitting restraints in the designated locations and to the lines and grades as shown on the drawings.

2. MATERIALS

2.1 Ductile Iron Pipe: Unless otherwise specified or shown on the drawings, ductile iron pipe shall be Wall Thickness Class 52 and shall conform to the latest revision of ANSI A21.51 – (AWWA C151) Standard for Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand Lined Molds, for Water or Other Liquids. The pipe shall be standard asphaltic varnish coated on the outside. Pipe shall be cement mortar lined in conformance with ANSI A21.4-80 – (AWWA C104) unless specified otherwise.

2.2 Fittings: The fittings to be used with ductile iron pipe may be with gray iron or ductile iron, and shall conform to the requirements of ANSI/AWWA C110-77. All fittings shall be coated and lined in the same manner as the pipe. All fittings up to and including 12 inches shall be Class 350, with all larger fittings of Class 250. Flanged fittings shall be Class 125 unless noted otherwise on the drawings. Mechanical joint and push-on joint fittings shall meet all applicable requirements of ANSI 21.11-79 – (AWWA C111).

2.3 Joints: Unless specifically noted otherwise, joints for ductile iron pipe that is to be buried shall be either a push-on type or a mechanical joint. Unless noted otherwise, joints for pipe used inside buildings or structures shall be either flanged or a lock coupling for grooved-end pipe.

2.3.1 Push-on Type Joint: The push-on type joints consisting of a single neoprene gasket which are acceptable are "Tyton" as manufactured and licensed by the U.S. Pipe and Foundry Company; "Fastite" as manufactured and licensed by the American Cast Iron Pipe Company and "Bell-Tite" as manufactured and licensed by James B. Clow and Son, Inc. All required joint materials including the neoprene gasket and the lubricant shall be furnished with the pipe.

2.3.2 Mechanical Joint: Mechanical joint ends shall comply with the requirements of ANSI A21.11-79 - (AWWA C111). All required joint materials including neoprene gasket, gland, bolts, and nuts shall be included with the pipe.

2.3.3 Flanged Joint: The flanged joint shall be integrally cast and shall conform to the requirements of ANSI Specification B16.1 for Class 125. Screw-on flanges will be acceptable, but any required threading of pipe barrel shall be done by the factory in conformance with AWWA C115 utilizing Class 53 pipe. Flanges shall be ductile iron. The pipe barrel and flange shall not be field assembled. The flanges shall be furnished with factory purchased full face gaskets 1/8-inch thick of SBR rubber per ANSI/AWWA C111/A21.11.

3. EXECUTION

3.1 Cutting, Cleaning, and Inspecting: All cutting of ductile iron pipe shall be done by a means of mechanical cutter. Wheel cutters shall be used whenever practical. After cutting, the interior of the pipe shall be thoroughly swabbed or cleaned of all foreign matter before being installed into the system and shall be kept clean during and after installation. Before installation of any pipe or fitting, each piece shall be inspected for defects and shall be rung with a light hammer to detect any cracks. All defective, damaged, or unsound pipe or fittings shall be rejected.

3.2 Installation:

3.2.1 Mechanical Joint: The last eight inches outside of the spigot and the inside of the bell of the mechanical joint of push-on fittings shall be thoroughly cleaned to remove oil, grit, excess coating, and other foreign matter from the joint, and then coated with a soap solution. The ductile iron gland shall then be slipped on the spigot end of the pipe with the lip extension of the gland toward the socket or bell end. The rubber gasket shall be coated with soap solution and placed on the spigot end in the bell. The gasket shall then be pressed into place with the bell. Care shall be taken to locate the gasket evenly around the entire joint. The ductile iron gland shall be moved into position for bolting. Nuts spaced 180 degrees apart shall be tightened alternately in order to produce an equal pressure on all parts of the gland.

3.2.2 Flanged Joint: When assembling the flange joint, the Contractor shall insure that the ring gasket is properly located and placed flat against the face of the flange. Flanges shall be assembled by alternately tightening bolts spaced 180 degrees apart in order to produce an equal pressure on all parts of the gland.

3.2.3 Restrained Joint: Installation of restrained joint fittings shall be in strict accordance with the manufacturer's printed literature.

1. GENERAL

1.1 Description: The work of this section shall consist of furnishing, hauling, storing, and installing solid wall polyvinyl chloride (PVC) plastic pipe for gravity sewers.

2. MATERIALS

2.1 Gravity Sewer Pipe (Main): PVC pipe for gravity sewer mains, 4" through 15" in diameter, shall meet the requirements of ASTM D3034, latest revision, SDR-35. PVC pipe for gravity sewers 18" through 24" diameter shall meet the requirements of ASTM F679, latest revision, Type 1, SDR-35. Pipe shall be extruded with one end to serve as a spigot end and the other as a bell end, with a gasket groove molded inside for retention of a rubber gasket used in making the joint. Joints shall meet the requirements of ASTM D3212. Standard laying lengths shall be 12.5 feet or 20 feet.

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

Nom. Size (In.)	Ft-Lbs.
4	150
6	210
8	210
10	220
12	220
15	220
18	220
21	220
24	220

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

2.1.3 Flattening: There shall be no evidence of splitting, cracking, or breaking when a specimen of pipe, six-inches long, is flattened between parallel plates in a suitable press until the distance between the plates is forty percent of the outside diameter of the pipe. The rate of loading shall be uniform and such that the compression is completed within two to five minutes.

2.2 Gravity Sewer Pipe (Lateral): PVC pipe for service laterals, 4" and 6" in diameter, shall be schedule 40 and shall meet the requirements of ASTM D1785, latest revision. Pipe joints shall be either bell and spigot with an elastomeric gasket or solvent weld.

2.2.1 Bell and spigot: Pipe for bell and spigot joints shall be extruded with one end to serve as a spigot end and the other as a bell end, with a gasket groove molded inside for retention of a rubber gasket used in making the joint. The joints shall comply with ASTM D3139, latest revision.

2.2.2 Solvent weld: Pipe for solvent weld joints shall comply with ASTM 2672, latest revision.

2.3 Pressure Rated Pipe: All PVC pipe utilized for pressure sewers shall meet the requirements of ASTM D2241 and shall be Class 200, SDR 21.

1. GENERAL

1.1 Description: The work of this section shall consist of installing the gravity sewers to the lines and grades shown on the drawings and as specified herein.

2. MATERIALS

2.1 Gravity Sewers: Gravity sewer lines shall be solid wall polyvinyl chloride (PVC) pipe meeting the requirements of Section 02622 - PLASTIC PIPE or ductile iron pipe (D.I.P.) meeting the requirements of Section 02615 - DUCTILE IRON PIPE AND FITTINGS. Where noted, gravity sewers shall be constructed of ductile iron pipe

2.2 Pressure Sewers: Pressure sewer lines shall be solid wall polyvinyl chloride (PVC) pipe meeting the requirements of Section 02622 - PLASTIC PIPE or ductile iron pipe (D.I.P.) meeting the requirements of Section 02615 - DUCTILE IRON PIPE AND FITTINGS. Where noted, pressure sewers shall be constructed of ductile iron pipe

2.3 Manholes shall be as specified in Section 02601 - PRECAST MANHOLES.

3. EXECUTION

3.1 Handling, Receiving and Delivery of Materials: All materials shipped by rail shall be carefully inspected for damage in transit in the cars. If damaged material is found, it shall not be unloaded except upon instructions from the official freight agent. In the event of damaged pipe, it may be lifted out of the cars and placed along the switch site, but no material shall be removed from the railroad company property. If materials are delivered by truck, they shall be inspected as they are unloaded. Damaged pipe shall not be left at the job site, but shall be removed promptly so that rejected material will not mistakenly be used in construction. All pipe, pipe fittings, and other accessories and materials shall be unloaded in such a way as to avoid damage due to shock. Under no circumstances shall pipe be dropped to the ground from cars or trucks. Special precautions shall be taken to prevent one pipe from striking another forcefully.

3.2 Storage: All materials shall be placed for storage in suitable places. As pipe is placed along the intended alignment of the trench, it shall be placed with bell ends facing the direction in which work will proceed (upstream), unless otherwise directed.

3.3 Pipe Inspection: Before pipe is lowered into the trench, the pipe shall be inspected for defects. Ductile iron pipe shall be rung with a light hammer to detect cracks. Any defective, damaged, or unsound pipe shall be rejected.

3.4 Pipe Cleaning: A thorough cleaning of each pipe section shall be done just before the section is lowered into the trench. A suitable swab shall be pushed through the pipe to insure that all foreign matter and dirt is removed from the inside of the pipe. The pipe shall be kept clean by approved means during and after laying.

3.5 Cutting Pipe: All cutting of pipe shall be done in a neat manner with the least amount of waste of pipe involved and without damage to existing or new pipe lines.

3.6 Pipe Alignment:

3.6.1 Sewers twenty-four inches (24") and less shall be laid with straight alignment between manholes. Alignment shall be checked by either using a laser beam or by lamping.

3.6.2 Curvilinear alignment of sewers larger than twenty-four inches (24") may be considered on a case-by-case basis provided compression joints are specified and ASTM or specific pipe

manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves which start and end at manholes. Curvilinear sewers shall be designed so as to provide a minimum velocity of two feet (2') per second when flowing full.

3.7 Pipe Installation: All pipes, pipe fittings, etc. shall be lowered into the trench piece by piece by means of derricks, ropes, or other suitable equipment. Under no circumstances shall pipe or other materials be dropped into the trench. The pipe shall be laid with bell holes upstream, i.e., in the direction of laying operations. Pipe shall be laid in a bed of granular stone as shown on the drawings and as specified in Section 02222 - GRANULAR STONE BEDDING AND BACKFILL. In all cases, full length joints of pipe shall be used except in making closures. Grade lines shown on the profile drawings are the internal invert lines of the sewer pipe. The pipe shall be laid on grade with a grade rod that has an iron heel for the invert and notches for the line stretched over the pipe between the grade boards. Pipe laying machines, laser beams, or other devices may be used in lieu of a grade rod so long as comparable results are achieved. Bedding and backfilling of the pipe shall be in accordance with Section 02221 - TRENCHING, BACKFILLING, AND COMPACTING. At the close of each day's work, or when pipe is not being laid, the end of the pipe shall be stopped to overcome possible uplift and prohibit contamination. Any pipe which settles before acceptance, or which is not in true alignment, shall be taken up and replaced by the Contractor at his expense.

3.8 Joints: At all pipe joints, the granular stone bedding shall be excavated sufficiently so that the pipe bell will not rest on the bedding materials, but all the weight of the pipe shall be evenly distributed along the entire length of the barrel of the pipe. Care shall be taken to insure that the joints of the pipe are clean and free of any foreign material, and constructed watertight at all points. Any leaks or other defects discovered at any time before the final acceptance of the work shall be immediately repaired, or that portion of the sewer rebuilt, if necessary.

3.9 Removal of Buildings, Structures, and Improvements: Where buildings, structures, improvements, or materials of value are encountered in the area where sewer line is to be installed, the Contractor shall provide for the removal, protection, and disposition of these elements. The Contractor shall consult with the Owner relative to the proposed means of removal. All fences disturbed during construction shall be restored to a condition at least equal to that which existed prior to construction, unless specifically directed otherwise by the drawings. Certain repaired fence sections shall require installation of a fence gate. Locations of these gates shall be as called out on the drawings. Gates shall conform to the details shown on the drawings.

3.10 Stream Crossing: Stream crossings shall be constructed with mechanical joint, ductile iron pipe unless shown otherwise on the drawings. The length of the crossing being determined by the Plan and Profile drawings.

3.10.1 Depth: Sewers shall be installed to the depths shown on the Plan & Profile drawings and shall be compliant with 10 CSR 20-8.120(8)(A).

3.10.2 Structures: All structures related to the sewer system shall be installed such that they are located so as not to interfere with the free discharge of flood flows of the stream.

3.10.3 Silt and Erosion Control: The City of Carthage Model Best Management Practices (BMP's) for Land Disturbance shall be utilized to control silt laden runoff from the project area. The contractor shall provide to the owner an erosion control plan with BMP's denoted. The owner shall determine if the proposal is acceptable. If the proposal is found to be unacceptable, the contractor shall re-work the proposal to address all areas of concern. The owner shall have ultimate authority to approve or disapprove any erosion control plan.

a. In all cases exposed areas shall not remain unprotected for more than seven (7) days.

3.11 Aerial Crossing: Sewers that must cross ditches, streams, gullies, etc., above ground shall be constructed of mechanical joint, ductile iron pipe. Each exposed joint of pipe shall have a minimum of two (2)

supports. Footings or foundations for each support shall be founded on undisturbed earth and the bottom of the footing/foundation shall be a minimum of 24" below grade.

3.11.1 Couplings shall be installed at each end of the transition from above-ground to below-ground sewers.

3.12 Separation of Sewer and Water Lines

3.12.1 Horizontal Distance: Sanitary sewers laid parallel to existing potable water lines, shall be installed to maintain at least ten feet horizontal separation between the sewer and water lines.

a. Deviation from the above requirement will be allowed in areas where horizontal separation cannot be maintained. In these cases the sewer may be installed closer to the water main, provided the water main is in a separate trench or on an undisturbed shelf located on one (1) side of the sewer and at an elevation so the bottom of the water main is at least eighteen inches (18") above the top of the sewer.

3.12.2 Vertical Distance: Sewers crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") between outside of the water main and the outside of the sewer. This shall be required whether the water main is above or below the sewer line. The crossing shall be arranged so the sewer joints will be equidistant and as far as possible from the water main joints.

a. Deviation from the above requirement will be allowed in areas where vertical separation cannot be maintained. In these cases sewers shall be constructed of ductile iron or pressure class 200 PVC (DR14) for ten feet each direction from the crossing point.

3.12.3 Where deviation from the proper clearance is required, the sewer shall be constructed of slip-on or mechanical joint pipe or be continuously encased and be pressure tested to on hundred fifty pounds per square inch (150 psi).

3.13 Separation of Manholes and Water Lines

3.13.1 Manholes shall be located at least ten feet (10') horizontally from any existing or proposed water main.

3.14 Lateral Sewers: The exact location of all tee or wye branches and other special pieces shall be carefully ascertained by the Owner before concealment by backfilling, by accurate measure from the center of the manhole next below in the same line of pipe; that a true and exact record may be preserved for future use.

a. No tee or wye branch or special piece shall be covered before its exact location has been noted and recorded. If the sewer is being laid within the street right-of-way, all laterals shall extend to the right-of-way line.
b. Tracer Wire: A #12 AWG solid copper tracer wire shall be installed with the lateral line from the building to the sewer main. The wire shall have an exposed pigtail near the building and shall be connected to a ½" x 4'-0" ground rod set near the tee or wye in the main.
c. Temporary Marker: A temporary wood 2" x 2" or equivalent will be required at the end of each lateral or tee extending from the lateral or tee to within two (2) to six (6) inches below the ground surface.

4. TESTING

4.1 General: Completed gravity and pressure sewer shall require pneumatic or hydrostatic testing for the purpose of locating potential infiltration and/or exfiltration within the system. Testing shall be as specified in Section 02749 - SEWER AND MANHOLE TESTING.

1. GENERAL

1.1 Description: The work of this section consists of pneumatic and hydrostatic testing of completed sewers, manholes and appurtenances for the purposes of measuring the amounts of infiltration and/or exfiltration prevailing or possible within any section of sewer line, any manhole or appurtenances. All acceptance tests for both sewer lines and manholes shall be conducted in the presence of the certifying engineer, his representative, or the city representatives.

2. MATERIALS AND EQUIPMENT

2.1 Pneumatic Testing Equipment: Equipment used shall meet the following minimum requirements:

2.1.1 Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.

2.1.2 Pneumatic plugs shall resist internal test pressures without requiring external bracing or blocking.

2.1.3 All air used shall pass through a single control panel.

2.1.4 Three individual hoses shall be used for the following connections:

2.1.5 From control panel to pneumatic plugs for inflation.

2.1.6 From control panel to sealed line for introducing the low pressure air.

a. From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

2.1.7 Equipment shall be equal to Cherne Air-Loc Equipment or approved equal.

2.2 Sewer Pipe Plugs: Shall be as manufactured by Cherne, Halliburton or approved equal.

2.3 Hydrostatic Testing Liquid: Shall be potable water or non-potable clean water. Raw sewage shall not be used.

2.4 Deflection Testing Equipment: Shall be rigid ball or mandrel with an outside diameter equal to 95 percent of the inside diameter of the line to be tested and shall have nine (9) or more odd number of flutes or points.

3. EXECUTION

3.1 Pneumatic Testing: The Contractor shall perform low pressure air testing on all sections of completed sewer, 6-inch through and including 24-inch diameters, in the presence of the Owner. It will be the responsibility of the Contractor to furnish and operate equipment capable of making the required tests. Testing methods and air leakage rates shall conform to ASTM C828-80T, Practice for Low-Pressure Test of Vitrified Clay Pipe or F1417-92 entitled Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines using Low-Pressure Air, or latest revision thereof, as a minimum. A copy of ASTM F1417-92 is included herewith for review.

3.1.1 Procedures, Above Groundwater Table: All pneumatic plugs shall be seal-tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25

psig. The sealed pipe shall be pressurized to 5 psig. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.

a. After a manhole to manhole reach of pipe has been backfilled and cleaned and pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psig greater than the average back pressure of any groundwater that may be over the pipe. At least two (2) minutes shall be allowed for the air pressure to stabilize.

b. After the stabilization period (3.5 psig minimum pressure in the pipe), the air hose from the control panel to the air supply shall be disconnected. The portion of line being tested shall be termed "Acceptable" if the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any groundwater that may be over the pipe) shall not be less than the time shown for the given diameters as found in ASTM F1417-92.

3.1.2 Procedures, Below Groundwater Table: In areas where groundwater is known to exist, the Contractor shall install a one-half diameter capped pipe nipple, approximately 10" long, through the manhole wall on top of one of the sewer lines entering the manhole. This shall be done at the time the sewer line is installed. Immediately prior to the performance of the test, the groundwater shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connecting a clear plastic tube to the nipple. The hose shall be held vertically and measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in this plastic tube. The height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11 ½ feet, then the added pressure will be 5 psig. This increases the 3.5 psig to 8.5 psig and the 2.5 psig to 7.5 psig. The allowable drop of one pound and the timing remain the same.)

3.2 Test Failures: If the sewer installation fails to meet these requirements, the Contractor shall, at his own expense, determine the source of leakage. He shall then repair or replace, at his own expense, all defective materials and/or workmanship.

3.3 Testing of Manholes: The Contractor will be required to make either hydrostatic or vacuum infiltration/exfiltration tests of all manholes in the presence of the City, to demonstrate that the manholes are free of leaks. Hydrostatic testing shall conform to ASTM C969. Vacuum testing shall conform to ASTM 1244.

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

a. Test plugs are to be placed in the end of each sewer pipe on the downstream and upstream side of each manhole and inflated to a maximum pressure of 16 psig. Plugs are to be thoroughly blocked to prevent them from blowing out. The manhole is to be filled with water to a level four and one-half feet (4 ½') above the groundwater level or seven (7') feet above the pipe invert, or 2 feet (2') minimum above top of manhole rim elevation, whichever is higher. Ten minutes shall then be allowed for absorption, after which the water level shall be brought back to the test elevation.

b. The specified head shall be maintained on the manhole for a period of eight (8) hours. Sufficient water shall be added to maintain this level. All water added shall be metered to within one-tenth of a gallon and recorded. The maximum allowable leakage shall be as specified herein.

c. The Contractor shall provide all water, pumping facilities, and metering facilities necessary to perform the tests. After each test, all test water is to be pumped out.

3.3.2 Vacuum Testing: An approved vacuum type manhole tester shall be used to test manhole. The manhole ring shall be installed and tested as part of the manhole.

a. The procedure for testing manholes shall be as follows:

Each manhole shall pass two tests; the first test shall be after assembly but prior to backfilling and the second test shall be after backfilling.

Place the vacuum "test head" assembly inside the manhole cover cast iron frame. The vacuum test shall include testing of the seal between the cast iron frame and concrete cone, slab or grade rings.

Plug all pipes entering the manhole at least eight inches into the sewer pipe. The plug must be inflated at a location past the manhole/pipe gasket.

Brace all plugs to prevent the plug or pipe from being dislodged and drawn into the manhole.

A vacuum of at least ten and one-half inches of mercury shall be drawn on the manhole. Shut valve on vacuum line to manhole and disconnect vacuum line. Open the vacuum line valve and adjust vacuum to ten inches of mercury.

The pressure gage shall be liquid filled and have a 3 ½ inch diameter face with a reading from zero to thirty inches of mercury. The test equipment shall be capable of having two gages connected. The gage supplied with the test equipment shall match the reading of a gage furnished by the Utilities Department. The gage reading is to be verified on each project.

The time for the vacuum reading to drop from ten inches of mercury to nine inches of mercury must be equal to or greater than the following values for the manhole to be considered as passing the vacuum test:

MANHOLE DEPTH	TIME (minutes)
10 feet or less	2
10.1 to 15 feet	2.5
15.1 to 25 feet	3

If vacuum drops less than one-inch mercury within the test time, the manhole is considered acceptable and passes the test. If manhole fails and leaks, the contractor shall make the needed repairs and test again until satisfactory results are obtained. Test may be done before backfilling, but shall be repeated after backfill.

All safety procedures, placing of plugs, and bracing, labor, and other work required for testing will be the responsibility of the contractor.

The contractor shall supply all required test plugs, vacuum plate, and vacuum pump.

3.4 Infiltration/Exfiltration Allowance:

3.4.1 Sewers 6" through 24" Diameter: Exfiltration of infiltration shall not be permitted to exceed 100 gallons per inch of pipe diameter per mile per day for any section of sewer and 1.14 gallon per day per foot of vertical depth per manhole.

a. After the air test is carried out, a measurement of any flow in the sewers shall be made by the Contractor, in the presence of the Owner, to determine if the flow is below 100 gallons per inch diameter per mile per day limitation. Hydrostatic testing of manholes may then be conducted.

b. Infiltration/exfiltration for manholes shall not exceed 1.14 gallons per day per vertical foot of manhole, determined by hydrostatic testing as specified by paragraph 3.2.

3.5 Infiltration/Exfiltration Elimination: The Contractor shall locate all sources of infiltration and exfiltration in the sewer lines, manholes, and appurtenances and shall correct deficiencies and eliminate infiltration/exfiltration sources. All sections of sewer line, manholes and appurtenances shall be re-tested after corrections are finalized. The Contractor shall carry the sole responsibility for providing a sewer system having infiltration or exfiltration below the specified limits.

4. DEFLECTION TEST ON FLEXIBLE PIPE

4.1 Deflection tests shall be performed on all flexible pipes. The test shall be conducted after the final backfill has been in place at least thirty (30) days.

4.2 No pipe shall extend a deflection of five percent (5%). If the deflection exceeds the five percent (5%) limit, the pipe shall be excavated. Replacement or correction shall be accomplished in accordance per the owner's direction.

4.3 Performance: The deflection test shall be performed by hand pulling a rigid ball or mandrel through the installed pipe in the presence of the Owner. The mandrel shall be pulled through the pipe without the aid of a mechanical pulling device. If the rigid ball or mandrel fails to pull through the pipe, the section being tested fails the test and will be replaced by the Contractor at no expense to the Owner.

Designation: F 1417 – 92 (Reapproved 2005)

An American National Standard

Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air[1]

This standard is issued under the fixed designation F 1417; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method provides procedures for testing plastic pipe sewer lines, using low-pressure air to prove the integrity of the installed material and the construction procedures. Two procedures are included to find the rate of air leakage—the constant-pressure method and the time-pressure drop method.

1.2 This test method shall be performed on lines after all connections and service laterals have been plugged and braced adequately to withstand the test pressure. The time between completion of the backfill operation and low-pressure air testing may be specified by the approving authority.

1.3 This test method also may be used as a preliminary test, which enables the installer to show the condition of a buried line prior to final backfill, paving, and other construction activities.

1.4 This test method is applicable to all gravity sewer lines made of thermoplastic pipe, reinforced thermosetting resin (RTRP) pipe, and reinforced plastic mortar (RPM) pipe, defined in Terminology D 883, D 1600, and F 412.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 5.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 828 Practice for Low-Pressure Air Test of Vitrified Clay Pipe Lines (4 to 12-in.)

C 924 Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method

D 883 Terminology Relating to Plastics

D 1600 Terminology for Abbreviated Terms Relating to Plastics

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D 3567 Practice for Determining Dimensions of Fiberglass (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

F 412 Terminology Relating to Plastic Piping Systems

2.2 *Uni-Bell PVC Pipe Association Standard:*

UNI-B-6-90 Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe[3]

3. Summary of Test Method

3.1 The section of the line to be tested is plugged. Air, at low pressure, is introduced into the plugged line. The line passes the test if the rate of air loss, as measured by pressure drop, does not exceed a specified amount in a specified time. Pressure drop may be determined by using Table 1 or Table 2, or calculated by use of the formulas in 9.1.

4. Significance and Use

4.1 This low-pressure air test detects damaged piping or improper jointing by measuring the rate at which air under pressure escapes from an isolated section of sewer.

4.2 The rate of air loss will indicate the presence or absence of damaged piping or leaking joints. This test method is not intended to show total system water leakage limits and cannot be used as a quantitative measure of leakage under service conditions for infiltration or exfiltration.

NOTE 1—A finding of acceptable air loss specified in this test method can be interpreted as an installation acceptance test in lieu of infiltration or exfiltration test.

4.3 This test method will ensure the best possible initial condition and quality workmanship of all property-installed sewer pipe.

5. Apparatus

5.1 *Plugs*—Mechanical or pneumatic type.

5.2 *Air Compressor*—A properly calibrated portable, oil-free air source with a singular control panel containing a main shut-off valve, pressure-regulating valve, 9 psig pressure-relief

[1] This test method is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Uni-Bell PVC Pipe Association, Suite 155, 2655 Villa Creek Drive, Dallas, TX 75234.

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TABLE 1 Minimum Specified Time Required for a 1.0 psig Pressure Drop for Size and Length of Pipe Indicated for $Q = 0.0015$

NOTE 1—See Practice UNI-B-6-90.
NOTE 2—Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 in. in diameter.

Pipe Diameter, in.	Minimum Time, min:s	Length for Minimum Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	3:46	597	0.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	0.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

TABLE 2 Minimum Specified Time Required for a 0.5 psig Pressure Drop for Size and Length of Pipe Indicated for $Q = 0.0015$

NOTE 1—Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 in. in diameter.

Pipe Diameter, in.	Minimum Time, min:s	Length for Minimum Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	0.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	0.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	0.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235 L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653 L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	64:54
30	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926 L	21:33	32:19	43:56	53:52	64:38	75:24	86:10	96:57
36	17:00	66	15.384 L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23

valve, input pressure gage, and a continuous monitoring pressure gage having a pressure range from 0 psi to at least 10 psi with minimum divisions of 0.10 psi and an accuracy of ± 0.04 psi.

5.3 *Rotameter*, standard CFM reading with an accuracy of ± 2 %.

6. Safety Precautions

6.1 This low-pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is overpressurized or plugs/caps are installed or restrained improperly. It is extremely important that the various plugs be properly installed to prevent the sudden expulsion of a poorly installed or partially inflated plug. Observe the following minimum safety precautions:

6.1.1 No one shall be allowed in the manholes during testing.

6.1.2 Install and restrain all caps and plugs securely.

6.1.3 When lines are tested, it is mandatory that all the caps and plugs be braced as an added safety factor.

6.1.4 Do not overpressurize the lines. Do not exceed 9.0 psig.

NOTE 2—The axial force on a plug at 4 psig internal pressure is $F = P \pi D^2/4$ lb, where D is the inside diameter in inches. Thus, the axial force on an 8-in. plug at the start of a properly-conducted test is over 200 lb. Restraint systems must be designed to handle these forces with adequate safety factors. Every effort should be made to maintain backfill over the pipe during air testing.

6.1.5 A regulator or relief valve set no higher than 9 psi shall be included on all pressurizing equipment.

7. Preparation of the Line

7.1 Clean the section of sewer line to be tested by flushing or other means prior to conducting the low-pressure air test. This cleaning serves to eliminate debris and produce the most consistent results.

8. Procedures

8.1 Isolate the section of sewer line to be tested by inflatable stoppers or other suitable test plugs.

8.1.1 Plug or cap the ends of all branches, laterals, tees, wyes, and stubs to be included in the test to prevent air leakage. All plugs and caps shall be securely braced to prevent

blow-out. One of the plugs or caps should have an inlet tap, or other provision for connecting a hose to a portable air control source.

8.1.2 Connect the air hose to the inlet tap and portable air control source. The air equipment shall consist of necessary valves and pressure gages to control an oil-free air source and the rate at which air flows into the test section to enable monitoring of the air pressure within the test section.

8.1.3 Add air slowly to the test section until the pressure inside the pipe reaches 4.0 psig.

8.1.4 After the pressure of 4.0 psig is obtained, regulate the air supply so that the pressure is maintained between 3.5 to 4.0 psig for at least 2 min depending on air/ground temperature conditions. The air temperature should stabilize in equilibrium with the temperature of the pipe walls. The pressure will normally drop slightly until equilibrium is obtained; however, a minimum of 3.5 psig is required.

8.2 Determine the rate of air loss by either the constant pressure method or the time-pressure drop method.

NOTE 3—All test pressures are measured as gage pressure, which is any pressure greater than atmospheric pressure. Since water produces a pressure of 0.43 psi for every foot of depth, air test pressures must be increased to offset the depth of ground water over the sewer line. If the ground water level is 2 ft or more above the top of the pipe at the upstream end, or if the air pressure required for the test is greater than 9-psi gage, the air test method should not be used. Before the air test method is used, the ground water level should be lowered by pumping or dewatering.

8.2.1 *Constant Pressure Method*—Add air until the internal air pressure of the sewer line is raised to 4.0 psig and the test pipe section is stabilized as in 8.1. Release the pressure to 3.5 psig to run the constant pressure test. The air-flow rate in standard cubic feet per minute is read directly by a rotameter. Convert this air-flow rate to actual cubic feet per minute of air leaking from the test section by using the absolute pressure and temperature in the test section. The requirements for air loss under the constant pressure method shall be considered satisfied if the air loss does not exceed the specified leakage rate in cubic feet per minute per square foot of internal pipe surface area.

8.2.2 *Time-Pressure Drop Method*—Air is slowly introduced into the section of pipe to be tested, until the air pressure is raised to approximately 4.0 psi and the test pipe section is stabilized as in 8.1. Disconnect the air supply and decrease the pressure to 3.5 psi before starting the test. Determine the time required for the pressure to drop from 3.5 psi to 2.5 psi, and compare this interval to the required time to decide if the rate of air loss is within the allowable. Minimum holding times required by pipe diameter are shown in Table 1 and Table 2.

NOTE 4—The time-pressure drop method assumes an atmospheric pressure of 14.7 psia. Locations of high altitude need compensation for variation in atmospheric pressure to maintain the same air leakage test criteria.

8.3 Upon completion of the test, open the bleeder valve and allow all air to escape. Plugs should not be removed until all air pressure in the test section has been reduced to atmospheric pressure.

9. Test Time Calculations

9.1 *Test Time Criteria*—No test section shall be accepted if air loss is more than a specified leakage rate (in cubic feet per minute per square foot) determined by the approving authority.

9.2 Calculate all test times by the following formula:

$$T = 0.085\,DK/Q$$

where:

T = shortest time allowed for the air pressure to drop 1.0 psig, s,
K = 0.000419 DL but not less than 1.0,
Q = leak rate in cubic feet/minute/square feet of internal surface = 0.0015 CFM/SF,
D = measured average inside diameter of sewer pipe (see Test Method D 2122 and Practice D 3567), in., and
L = length of test section, ft.

Table 1 contains the specified minimum times required for a 1.00 psig pressure drop from a starting pressure of 3.5 psig to a final pressure of 2.5 psig using a leakage rate of 0.0015 $ft^3/min/ft^2$ of internal surface.

9.3 The total leakage from any test section shall not exceed $625Q$.

9.4 If the pressure drops 1.0 psig before the appropriate time shown in Table 1 has elapsed, the air loss rate shall be considered excessive and the section of pipe has failed the test. If the line fails the test, segmented testing may be utilized solely to find the location of leaks. Once leaks are located and repaired, retest the completed pipe installation to requirements of this test method.

9.5 For testing of long sections or sections of larger diameter pipes, or both, a timed-pressure drop of 0.5 psig shall be used in lieu of a 1.0 psig timed-pressure drop. If a 0.5 psig pressure drop is used, the appropriate required test time shall be exactly one-half the values shown in Table 1. (See Table 2.)

NOTE 5—It is not necessary to hold the test for the entire period of time in Table 1 or Table 2 when it is evident that the rate of air loss is zero or less than the allowable, and is authorized by the approving authority.

9.6 If lateral or service lines are included in the test, their length may be ignored for computing required test time if the test time requirements are met. The maximum permissible air loss should not exceed $625Q$. If the test section fails, time shall be recomputed to include all the lateral lengths using the following formula:

$$T = 0.085\left[\frac{D_1^2L_1 + D_2^2L_2 + \ldots + D_n^2L_n}{D_1L_1 + D_2L_2 + \ldots + D_nL_n}\right]\frac{K}{Q}$$

where:

T = shortest time allowed for the air pressure to drop 1.0 psig, s,
K = 0.000419 $(D_1L_1 + D_2L_2 + \ldots + D_nL_n)$, but not less than 1.0,
Q = 0.0015 CFM/SF,
$D_1, D_2, etc.$ = nominal diameter of different size of pipe being tested, and
$L_1, L_2, etc.$ = respective lengths of the different size pipes being tested.

If the recomputed test time is short enough to allow the section tested to pass, then the test section meets the requirements of this test method.

10. Precision and Bias

10.1 This test method provides qualitative data only; therefore, a precision and bias statement is nonapplicable.

11. Keywords

11.1 air test; plastic; sewer

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES

X1.1 In order to show the technique of applying this test method, the following examples have been prepared. The examples have been designed to illustrate the use of Table 1 and Table 2 and the formula in 9.1 that uses a leakage rate of 0.0015 CFM/ft^2.

X1.2 A manhole-to-manhole reach of nominal 12 in. pipe is 350 ft long. No lateral connections exist in the reach. What is the required test time for a 1.0 psig pressure drop?

X1.2.1 *Solution*—The required test time can be read directly from Table 1. For 350 ft of 12 in. pipe, the required test time is 19:56 (19 min and 56 s).

X1.3 A 350 ft section of nominal 12 in. pipe is ready for testing. A total of 128 ft of 4 in. lateral sewer pipe is connected to the 350 ft section and will be included in the test. What will be the required test time for a 0.5 psig pressure drop?

X1.3.1 *Solution*—Lateral sewers may be disregarded when selecting test times (see 9.1). Therefore, the required test time will be 9 min and 58 s as shown in Table 2.

NOTE X1.1—If the lateral sewers had not been disregarded, the required test time would be 10 min and 22 s, that is, only 24 s longer.

X1.4 What should the required test time be for a 1.0 psig pressure drop in 327 ft of nominal 8 in. diameter pipe between two manholes?

X1.4.1 *Solution*—The exact test time is easily calculated by using Table 1. Table 1 is used because a 1.0 psig pressure drop is specified. Since 327 ft exceed the 298 ft length associated with the minimum test time for an 8 in. pipeline, the fourth column in Table 1 is used to calculate the required test time as follows:

$$T = 1.520 \times L = 1.52 \times 327 = 497 \text{ s}$$

Therefore, the required test time for a 1.0 psig pressure drop is 497 s or 8 min and 17 s.

X1.5 A manhole-to-manhole reach of nominal 24 in. pipe is 82 ft long. What is the required test time for a 0.5 psig pressure drop?

X1.5.1 *Solution*—Table 2 is used because a 0.5 psig pressure drop is specified. Since 82 ft is less than the 99 ft length associated with the minimum test time for a 24 in. pipeline, the minimum test time shall apply. Thus, the required test time for a 0.5 psig pressure drop is 11:24 (11 min and 24 s).

X1.6 A 412 ft section of nominal 15 in. sewer pipe has been readied for air testing. A total of 374 ft of nominal 6 in. lateral piping and 148 ft of nominal 4 in. lateral piping branch off the 15 in.-sewer line. All laterals have been capped or plugged, or both, and will be tested together with the 15 in. main line. The specified pressure drop, which will be timed, is 0.5 psig. What is the appropriate test time for this pipe network?

X1.6.1 *Solution*—All lateral sewer sizes and lengths may be disregarded since their influence is generally not significant enough to warrant computation. Table 2 is used for a 0.5 psig pressure drop. The fourth column in the table gives the appropriate formula for calculating the required test time because 412 ft is longer than the third column value of 159 ft.

$$T = 2.671L = 2.671 \times 412 = 1100 \text{ s}$$

The required test time is 1100 s or 18 min and 20 s.

X1.7 A manhole-to-manhole reach of nominal 8 in. pipe is only 100 ft long. A total of 300 ft of nominal 4 in. lateral piping is connected to the 100 ft section and will be included in air testing the section. What will be the required test time for a 1.0 psig pressure drop?

X1.7.1 *Solution*—The required test time can be read directly from Table 1. Thus, for 100 ft of 8 in. pipe, the required holding time is 7:34 (7 min and 34 s). However, should the section fail to meet this test, recalculate the required holding time, taking into account the connected laterals. This recalculation is required because the total internal pipe surface area is less than 625 ft^2.

$$\text{Total area} = \pi\left[\frac{D L_1 + D L_2 + \ldots + D_n L_n}{12}\right]$$

$$= \pi\left[\frac{(8 \times 100) + (4 \times 300)}{12}\right] = 524 \text{ ft}^2$$

Using the equation provided in 9.1, the required test time should be recomputed as follows:

$K = 0.000419\,[(8 \times 100) + (4 \times 300)]$

$= 0.838$

$0.838 = 1.0 \longrightarrow K = 1.0$

NOTE X1.2—K will always be 1.0 when the total area is less than 625 ft^2.

$$T = = 0.085\left[\frac{(8^2 \times 100) + (4^2 \times 300)}{(8 \times 100) + (4 \times 300)}\right]\frac{1.0}{0.0015}$$

$T = 317$

The required test time is actually only 317 s or 5 min and 17 s for a 1.0 psig pressure drop. Therefore, if the section can meet this test time, it shall be accepted.

NOTE X1.3—For a specified 0.5 psig pressure drop, the test holding time would be only half as long, that is 2 min and 38 s.

X2. RATIONALE

X2.1 Low-pressure air testing is a fully accepted means of testing sewer lines. (Refs 1, 2, and 3)[4]

X2.2 It is true that due to the differing physical properties of water and air, no direct numerical correlation exists between air loss and water leakage. This does not mean that the two are unrelated. It has been established that lower air loss rates are associated with lower leakage rates.

X2.3 The data in these studies are based on installed sewer of concrete, clay, and asbestos cement sanitary sewers and were useful in deriving Practices C 828 and C 924.

[4] The boldface numbers in parentheses refer to the references listed at the end of this test method.

REFERENCES

(1) Hobbs, S. H., and Cherne, L. G., "Air Testing Sanitary Sewers," *WPCF Journal*, April 1968.

(2) Ramseier, R. E., "Low Pressure Air Test for Sanitary Sewers," *Journal of the Sanitary Engineering Division*, ASCE, April 1964.

(3) Ramseier, R. E., "Testing New Sewer Pipe Installation," *Water Pollution Central Federation Journal*, April 1972.

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CONCRETE FORMWORK 03100

1. GENERAL

1.1 Description: The work of this section consists of furnishing all materials, labor, tools and equipment necessary to construct all required form work to the lines and grades shown on the plans.

2. MATERIALS

2.1 All forms for exposed surfaces shall be built of sound plywood or other materials approved by the Engineer, closely fitted to provide the best surface possible without special lining.

2.2 Forms for surfaces not exposed may be built of sound lumber free from loose knots.

2.3 Form accessories to be partially or wholly embedded in the concrete, such as ties and hangers, shall be commercially manufactured type. The portion remaining within the concrete shall leave no metal within one inch of any surface which will be exposed to view.

3. EXECUTION

3.1 Forms: Forms shall conform to the shape, lines and dimensions of the concrete as shown on the Plans. Forms shall be provided for all vertical surfaces. The materials, design, and construction of formwork shall conform to the applicable portions of the American Concrete Institute Standard "Recommended Practice for Concrete Formwork" (ACI 347) and to these specifications.

3.2 Design: The design of the formwork shall be the responsibility of the Contractor.

3.3 Construction: Forms shall be built true to line and shall be mortar-tight and sufficiently rigid to prevent displacement or bulging between supports. Bends, chamfers and other offsets shall be provided when the forms are built. Joints shall be kept to a minimum and all joints shall be solidly backed by framing.

3.4 Preparation of Surfaces: Before forms are placed, material to form exposed surfaces shall be oiled thoroughly, and for unexposed concrete, forms may be oiled at the Contractor's option. All forms not oiled shall be wetted immediately before placing concrete. All formwork shall be cleaned free of dirt and construction debris before placing concrete and points at which water has gathered within the forms due to wetting shall be drained.

3.5 Removal of Forms: Formwork for walls, sides of slabs and other parts not supporting the weight of the concrete may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.

3.6 Embedded Items, Opening, and Recesses:

3.6.1 General: All sleeves, inserts, grooves, anchors, recesses, and other items required for adjoining work or for its support shall be placed or formed prior to placing the concrete.

3.6.2 Related Trades: All of the various trades shall be given ample opportunity to furnish for installation all hangers, anchors, inserts, sleeves, frames and other items to be built into the concrete as shown on the Plans or the various manufacturers' drawings or specified herein.

3.6.3 Placing Embedded Items: Expansion joint material, waterstops and all other embedded items shall be positioned accurately and supported securely against displacement before placing concrete.

3.6.4 Formed Holes: Formed holes shall be formed with non-ferrous material which shall be removed after the concrete has hardened.

3.7 Formwork for beams, slabs and other parts that support the weight of concrete and construction live loads shall remain in place until the concrete has reached its specified 28-day strength. Formwork that supports the weight of concrete only, and no construction live loads, or other loads, shall remain in place for not less than seven (7) days or until the concrete has reached 75 percent of its specified 28-day strength. The concrete shall be presumed to have reached its strength when either of the following conditions has been met.

3.7.1 When test cylinders, field cured under the most unfavorable conditions prevailing for any portion of the concrete represented, have reached the required strength. Except for field curing and age at test, the test cylinders shall be taken and tested as specified herein.

3.7.2 When the concrete has been cured as specified herein for the same length of time as the age at test of laboratory-cured cylinders which reached the required strength. The length of time the concrete has been cured in the field shall be determined by the cumulative number of days or fractions thereof, not necessarily consecutive, during which the temperature of air in contact with the concrete is above 50°F, and the concrete has been damp or thoroughly sealed from evaporating and loss of moisture.

3.8 Contractor's Responsibility: In all cases, the Contractor shall be solely responsible for adequate support of the forms to safely carry the load of concrete without undue deflection. The Contractor shall be liable for injury or damage resulting from inadequate forms, falsework or from premature removal of same.

CONCRETE REINFORCEMENT 03200

1. GENERAL

1.1 Description: The work of this section consists of furnishing, hauling all reinforcement materials and all tools, labor, equipment and incidentals necessary to complete this section.

2. MATERIALS

2.1 Reinforcing Steel: Reinforcing bars shall conform to the "Standard Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement", ASTM A615 or to the "Standard Specifications for Axle-Steel Deformed Bars for Concrete Reinforcement", ASTM A617 and shall be Grade 40, as designated on the plans.

2.2 Welded Wire Fabric: Welded wire fabric shall conform to "Standard Specifications for Welded Steel Sire Fabric for Concrete Reinforcement", ASTM A185.

3. EXECUTION

3.1 General: Unless otherwise indicated on the Plans or specified herein, all cutting and bending or reinforcement bars shall be done at the mill or ship prior to shipment. Cutting and bending in the field will be permitted only where shown on the plans or to correct errors, damage by handling and shipping, and minor omissions in shop bending when authorized by the Resident Project Representative.

3.2 Storing and Cleaning:

3.2.1 All reinforcement shall be stored above ground on skids, pallets or other supports and shall be protected from mechanical injury and from deterioration by exposure.

3.2.2 When placed in the work, reinforcement shall be free from dirt, detrimental scale, concrete, paint, oil or other foreign materials. Tight, thin rust is not considered detrimental and will not require cleaning.

3.3 Placing: Except as shown on the Plans or specified herein, all placement of reinforcing bars, welded wire fabric and bar supports shall conform to the latest editions of "Placing Reinforcing Bars, CRSI-WCRSI Recommended Practices", published by the Concrete Reinforcing Steel Institute. Bars may be moved as necessary to avoid interference with other reinforcing steel, pipes and other embedded items. If bars are moved more than the specified placing tolerances, the resulting arrangement shall be approved by the Resident Project Representative.

3.4 Splices: When splices other than those shown on the plans become necessary, they shall be located at areas of low stress and shall be subject to approval by the Resident Project Representative.

CAST-IN-PLACE CONCRETE 03300

1. GENERAL

1.1 Description: The work of this section shall include the furnishing, hauling, placing, curing, and testing of all Portland Cement Concrete required by the Construction Drawings and herein specified.

2. MATERIALS

2.1 Portland Cement: Portland cement shall conform to "Standard Specifications for Portland Cement: ASTM C150 Type 1 or Type 1A when specified. One sack of cement shall be considered as one cubic foot of volume or 94 pounds by weight.

2.2 Aggregates: Fine and coarse aggregates shall conform to "Standard Specifications for Concrete Aggregates", ASTM C33. The nominal maximum size of the coarse aggregate shall not be larger than one-fifth of the narrowest dimension between sides of forms, one-third the depth of the labs, nor three-fourths of the minimum clear distance between reinforcing bars or between bars and forms, whichever is lest. Coarse aggregate gradation shall conform to ASTM C33 Size 67 for class B.

2.3 Admixtures: Air-entrained admixtures shall conform to "Standard Specifications for Air-Entraining Admixtures for Concrete", ASTM C260. The Contractor shall submit a manufacturer's certification and guarantee to the Engineer showing the brand name and designation, the composition or description of the air-entraining agent will conform the requirements of these specifications. Water-reducing, retarding, or accelerating admixtures, if permitted by the Resident Project Representative, shall conform to "Standard Specifications for Chemical Admixtures for Concrete", ASTM 494. The use of calcium chloride in concrete mixtures will not be permitted.

2.4 Mixing Water: Mixing water for concrete shall be fresh, clean and potable. Non-potable water may be used only if it produces mortar cubes having 7- and 28- day strengths equal to the strength of similar specimens made with distilled water, when tested in accordance with "Method of Test for Compressive Strength of Hydraulic Cement Mortars", ASTM C109.

2.5 Water Stops:

2.5.1 Water stops shall be provided for construction joints where noted on the Plans. Water stops shall be manufactured in accordance with ASTM D-471 and shall made of thermoplastic elastomeric rubber, specifically designed for aggressive chemicals including liquid nitrogen.

2.5.2 The thermoplastic elastomeric rubber water stops shall be WESTEC, Style #618 or #637 water stops, as manufactured by WESTEC Barrier Technologies, or approved equal.

2.6 Curing Compounds: All curing compounds shall conform to specifications for liquid membrane forming compounds for curing concrete ASTM C309 for Type 1-D clear or translucent with fugitive dye or Type 2 white pigmented, and shall be applied in accordance with manufacturer's recommendations.

2.7 Reinforcement: Reinforcing steel shall conform with Section 03200.

3. PROPORTIONING CONCRETE

3.1 General: Proportions of aggregate to cement and water shall be such to provide a concrete mix which will work readily into corners and angles for forms and around reinforcement and other embedded items without causing segregation of materials.

3.2 Proportioning Ingredients: All ingredients shall be proportioned in order to obtain the following:

Class of Concrete	Type of Concrete	Min. 28-Day Com. Strength	Water-Cement Ratio (maximum)	Maximum Slump (inches)
B-1	Structural	3,500 psi	5.25 gal/sack	4

Air Entrainment

4% to 7% by volume of air-entrainment for all classes of concrete.

3.2.1 In no case shall be amount of fine aggregate be more than the amount of coarse aggregate (measured by weight) nor shall the amount of coarse aggregate be such as to produce honeycombing.

3.2.2 Portland cement concrete shall be proportioned and placed to provide an average compressive strength sufficiently high to minimize the number of compressive strength tests falling below the specified compressive strength for the concrete structure. Portions of concrete ingredients, including water-cement ratios, shall be established on the basis of laboratory trial batches to provide conformance with compressive strength requirements, workability, and consistency. When different materials are used for difference portions of the project, each combination shall be evaluated separately. Strength tests shall be conducted on test specimens in accordance with ASTM C39 and ASTM C192, from the trial batches using different water-cement ratios. Tabular data showing the compressive strength of the concrete proportions with various water-cement ratios shall be provided to the Engineer prior to placing of concrete on the jobsite.

3.2.3 Concrete shall be provided to develop a minimum 28-day compressive strength for field cured cylinders for each class of concrete indicated. Concrete that, after curing, will be subjected to freezing temperatures while wet shall contain entrained air from 4.0 to 7.0 percent by volume. Concrete that is intended to be water-tight shall have a maximum water-cement ratio of 0.48 by weight.

3.3 Moisture: Moisture in the aggregate shall be measured and the quantity must be included in the water-cement ration specified above.

3.4 Air-Entrainment: Air-entrainment shall be accomplished by the use of Type 1 Portland Cement with the addition of an approved air-entrainment admixture or by the use of Type 1A Portland Cement, as specified herein.

3.5 Trial Batches: Full sized trial batches shall be made in the laboratory using the aggregates selected for the job to establish the correct proportions to give proper workability, strength, and texture with the water-cement ration specified. The combinations of fine and coarse aggregates shall be adjusted within limits specified in ASTM C33 until the mix meets approval of the Engineer.

3.6 Water-Reducing, Retarding & Accelerating Admixtures: Such admixtures may be used when such use is requested by the Contractor subject to review and approval by the Engineer. For certain uses the Engineer reserves the right to require the use of a retardant or other admixtures for specific uses such as a retardant in extensive wall pours to assure elimination of cold joints or for other such purposes. No additional compensation will be allowed when such admixtures are used either at the Contractor's request or at the request of the Engineer. However, when certain such admixtures are used, it will be allowable to reduce the cement content of the mix to a minimum of 5 ½ bags of cement per cubic yard of concrete subject to the following conditions: A trial batch and test cylinders taken therefrom demonstrate that the mix will meet the strength, workability, slump and durability requirements of the specified mix previously herein stated. The strength shall be determined from seven-day test cylinders from a trial batch utilizing the admixture and made using the aggregates selected from the job, to establish the correct proportions to give proper workability with the water-cement ratio specified. The combination of fine

and coarse aggregates shall be adjusted within limits specified to equal 95 percent of the specified minimum 28-day strength.

4. MIXING CONCRETE

4.1 Ready-Mixed Concrete: Ready-mixed concrete will be permitted provided it conforms to the "Standard Specification for Ready-Mixed Concrete", ASTM C94 and to the applicable portions of these Specifications. The Contractor shall make all arrangements to satisfy the Engineer that materials used comply with specification requirements.

4.1.1 The Engineer shall have free access to the mixing plant at all times when work is performed for this project for sampling and testing materials. Such privilege shall not relieve the Contractor of his responsibility for compliance with contract requirements.

4.2 Batch Mixing at Site:

4.2.1 The concrete shall be mixed in a batch mixer, conforming to the requirements of the Mixer Manufacturer's Bureau of the Associated General Contractors of America. The mixer shall bear a manufacturer's rating plate indicating the rated capacity and the recommended revolution per minute and shall be operated in accordance with these recommendations. It shall be equipped with a suitable charging hopper, water storage tank, and a water-measuring device and shall be capable of thoroughly mixing aggregates, cement and water into a uniform mass within the specified mixing time and discharging the mix without segregation.

4.2.2 The batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to insure that the batch cannot be discharged until the required mixing time has elapsed. Controls shall be provided to insure that no additional water may be added during mixing. The entire batch shall be discharged before the mixer is recharged.

4.2.3 Each batch of two cubic yards or less shall be mixed for not less than 1 ½ minutes. The minimum mixing time shall be increased 15 seconds for each additional cubic yard or fraction thereof.

4.3 The mixer shall be clean, and the pick-up and throw-over blades shall be replaced when they have lost 10 percent of their original depth.

4.4 Admixtures:

4.4.1 Air-entraining and chemical admixtures shall be charged into the mixer as a solution and shall be dispensed by an automatic dispenser or similar metering device. Powered admixtures shall be weighted or measured by an admixture shall be with +/- three percent.

4.4.2 Two or more admixtures may be used in the same concrete, provided such admixtures are added separately during the batching sequence and provided further that the admixtures used in that combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

4.4.3 Addition of retarding admixtures shall not be significantly delayed after the addition of the cement.

4.5 Retempering: Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be retempered, but shall be discarded.

4.6 Indiscriminate addition of water to increase slump or workability shall be prohibited. When concrete arrives at the project with slump below that suitable for placing, water may be added only if neither the maximum permissible water-cement ration nor the maximum slump is exceeded. The water must be incorporated by additional mixing equal to at least half of the total mixing required. Any addition of water above that permitted by the limitation on water-cement ration must be accompanied by a quantity of cement sufficient to maintain the proper water-cement ration. Such addition must be approved by the Engineer.

4.7 Weather Conditions:

4.7.1 Cold Weather: To maintain the temperature of the concrete above the minimum placing temperature required herein, the as-mixed temperature shall not be less than 55°F. when the mean temperature falls below 40°F.

4.7.2 If the water or aggregate has been heated, the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be added to the mixtures of water and aggregate when the temperature of the mixture is greater than 100°F.

4.7.3 Hot Weather: The ingredients shall be cooled before mixing if necessary to maintain the temperature of the concrete below the maximum placing temperature required herein.

5. CONCRETE PLACEMENT

5.1 Preparation Before Placing: Hardened concrete and foreign materials shall be removed from the inner surfaces of the conveying equipment.

5.2 Formwork shall be completed; reinforcement shall be secured in place; expansion joint material, waterstops, anchors, pipe sleeves, and other embedded items shall be positioned; and the entire preparation shall be approved by the Resident Project Representative before any concrete is placed. Subgrades shall be sprinkled sufficiently to eliminate absorption of water from the concrete before any concrete is placed.

5.3 Conveying: Concrete shall be handles from the mixer to the place of final deposit as rapidly as practicable by methods which will prevent separation or loss of ingredients and is a manner which will assure that the required quality of the concrete is obtained.

5.4 Conveying equipment shall be of size and design to insure a continuous flow of concrete at the delivery end and shall be approved by the Resident Project Representative. Conveying equipment and operations shall conform to the following requirements:

5.4.1 Truck mixers, agitators, and nonagitating units and their manner of operation shall conform to the applicable requirements of "Specifications for Ready-Mixed Concrete", ASTM C94.

5.4.2 Belt conveyors shall be horizontal or at a slope which will not cause segregation or loss. An approved arrangement shall be used at the discharge end to prevent separation. Long runs shall be discharged without separation into a hopper.

5.4.3 Chutes shall be metal or metal-lined and shall have a slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal. Chutes more than 20 feet long and chutes not meeting the slope requirements may be used provided they discharge into a hopper before distribution.

5.4.4 Pumping or pneumatic conveying equipment shall be without "Y" sections, and with adequate pumping capacity. The equipment shall be cleaned at the end of each operation. Pneumatic

placement shall be controlled so that separation is not apparent in the discharged concrete. The maximum loss of slump in pumping or pneumatic conveying equipment shall be 1 ½ inches.

5.5 Depositing: Concrete shall be deposited continuously or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams or plans of weakness within the section. If a section cannot be placed continuously, construction joints shall be located at points as provided for in the drawings or as approved by the Resident Project Representative. Placing shall be carried on at such a rate that the concrete which is being integrated with fresh concrete is still plastic. Concrete which has partially hardened or has been contaminated by foreign materials shall not be deposited. Temporary spreaders in forms shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. They may remain embedded in the concrete only if made of metal or concrete and if prior approval has been obtained.

5.5.1 Placing of concrete in supported elements shall not be started until the concrete previously placed in columns and walls is not longer plastic.

5.5.2 Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to flowing or rehandling and shall drop vertically into the center of the forms. In no case shall concrete be allowed to fall more than five feet or at other times when required by the Resident Project Representative drop chutes or other approved devices shall be used.

5.6 Where surface mortar is to be the basis of the finish, the coarse aggregate shall be worked back from the forms with a suitable tool so as to bring a full surface of mortar against the form without the formation of excessive surface voids. All concrete shall be consolidated by vibration, spading, rodding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting or plans of weakness. Mechanical vibrators shall have a minimum frequency of 7,000 revolutions per minute and shall be operated by competent workmen. Overvibrating and use of vibrators to transport concrete within forms shall not be allowed. Vibrators shall be inserted and withdrawn at many points, from 18 to 30 inches apart. At each insertion the duration shall be sufficient to consolidate the concrete but not sufficient to cause segregation, generally from 5 to 15 seconds duration. A spare vibrator shall be kept on the job site during all concrete placing operation.

5.7 Weather Conditions:

5.7.1 Unless adequate protection is provided and approved by the Engineer, concrete shall not be placed in rain, sleet, or snow. Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

5.7.2 When the mean daily temperature falls below 40°F., the minimum temperature of concrete as place shall be 50°F.

5.7.3 Concrete deposited in hot weather shall have a placing temperature which will not cause difficulty from loss of slump, flash set or cold joints (usually somewhat less than 90°F.).

5.8 Concreting Under Water: No concrete shall be placed under water without the approval of the Engineer.

6. JOINTS

6.1 Construction Joints: Construction joints shown on the plans are recommended and any deviation from these shall be approved by the Engineer. When joints not shown on the plans are required, they shall be placed so as to least impair the strength of the structure.

6.1.1 All reinforcing bars and welded wire fabric shall continue across construction joints. Construction joints shall conform to the details shown on the plans and shall be keyed as shown.

Construction joints shall be thoroughly wetted and coated with a mixture of 1:2 mortar immediately before the new concrete is placed.

6.1.2 The surface of the concrete at all joints shall be thoroughly cleaned and all laitance shall be removed. Immediately before placing fresh concrete, the surface of the existing concrete at the joint shall be dampened but not saturated. The edges of all joints which are exposed to view shall be carefully finished true to line and elevation.

6.2 Expansion Joints:

6.2.1 Reinforcement or other embedded metal items bonded to the concrete shall not be permitted to extend through any expansion joint.

6.2.2 Premolded expansion joint filler shall be of the size shown on the plans and shall conform to "Specifications for Preformed Expansion Joint Filler for Concrete (Standard Cork, Type II)", ASTM. The joint shall be sealed as specified below.

6.3 Water Stops: Each piece of thermoplastic elastomeric rubber waterstop shall be of maximum practicable length in order that the number of splices be held to a minimum. Joints at intersections and at ends of pieces shall be made according to the manufacturer's recommendations and shall develop watertightness fully equal to that of the continuous waterstop material. Care shall be taken during installation of the waterstops so that no leakage will occur across the joint.

6.4 Joint Sealer:

6.4.1 Horizontal joints shall be sealed with a two-part, cold-applied urethane joint sealant. Sealant shall be self-leveling and shall conform to Federal Specification TT-S-00227E, Type I, Class A. Joint sealant shall be SEALTIGHT POURTHANE as manufactured by W.R. Meadows, Inc., or approved equal.

6.4.2 Vertical joints shall be sealed with a two-component, gun-grade, non-sag urethane joint sealant. Sealant shall conform to Federal Specification TT-S-00227E, Type II, Class A. Joint sealant shall be SEALTIGHT Dualthane, as manufactured by W.R. Meadows, Inc., or approved equal.

7. FINISHES

7.1 General: After removal of forms the concrete shall be given one or more of the finishes specified herein.

7.2 All necessary patching shall have been done immediately after forms have been removed and rubbing shall be completed not later than the following day. Surfaces shall be wetted and rubbed with carborundum brick or other abrasive until a uniform color and texture are produced. No cement grout or slush shall be used other than the cement paste drawn from the green concrete itself during the rubbing process.

7.3 Related Uniformed Surfaces: Tops of walls and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be floated to a texture reasonably consistent with that of the formed surfaces. Final treatment on formed surfaces shall continue uniformly across the unformed surfaces.

7.4 Sidewalk slabs shall be given a coarse transverse scored texture by drawing a broom or burlap belt across the surface. This operation shall follow immediately after floating.

8. PATCHING

8.1 General: All tie holes and all repairable defective areas shall be patched immediately after form removal.

8.2 Defective Areas: All honeycombed and other defective concrete shall be removed down to sound concrete. The area to be patched and an area at least six inches wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately one part cement to one part fine sand passing a No. 30 mesh sieve, shall be mixed to the consistency of thick cream and shall then be well brushed into the surface.

8.3 The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 1 ½ parts sand by damp loose volume. White portland cement shall be substituted for a part of the gray portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete as determined by a trial patch.

8.4 The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel without addition of water until it has reached the stiffest consistency that will permit placing.

8.5 After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least one hour before being finally finished. The patched area shall be kept damp for seven days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.

8.6 Tie Holes: After being cleaned and thoroughly dampened, the tie holds shall be filled solid with patching mortar.

8.7 Proprietary Materials: If desired by the Contractor, proprietary compound for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations and shall be Standard Dry Wall products, or approved equal.

9. CURING AND PROTECTION

9.1 General: Exposed surfaces of concrete shall be protected from premature drying and excessively hot or cold temperatures for the period of time necessary for the hydration of the cement and proper hardening of the concrete.

9.2 Curing: Initial curing shall immediately follow the finishing operation. Concrete shall be kept continuously moist at least for 24 hours by one of the following materials or methods:

9.2.1 Ponding or continuously sprinkling.

9.2.2 Absorptive mat or fabric kept continuously wet.

9.2.3 Sand or other covering kept continuously wet.

Whichever of the above materials or methods is chosen shall be approved by the Engineer.

9.3 Immediately following the initial curing and before the concrete has dried, final curing shall be accomplished by one of the following materials or methods:

9.3.1 Continuation of method used for initial curing.

9.3.2 Waterproof paper conforming to "Specifications for Waterproof Paper for Curing Concrete", ASTM C171.

9.3.3 Other moisture retaining coverings as approved by the Engineer.

9.4 The final curing shall continue for a cumulative number of seven days, not necessarily consecutive, during which the temperature of air in contact with the concrete is above 50°F. If high-early-strength cement has been used, the final curing shall continue for a total of three days. When the mean daily temperature of the atmosphere is less than 40°F., the temperature of the concrete shall be maintained between 50°F. and 70°F. for the required curing period. When necessary, arrangements for heating, covering, insulating or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature and moisture conditions without injury due to concentration of heat or carbon dioxide build up.

9.5 During hot weather, arrangements for installation of windbreaks, shading, spraying, sprinkling, ponding or wet covering shall be made in advance of placement and such protective measures shall be taken as quickly as concrete hardening and finishing operations will allow.

9.6 Changes in temperature of the concrete shall be as uniform as possible and shall not exceed 5°F. in any one hour or 50°F. in any 24-hour period.

9.7 Protection From Mechanical Injury: During curing the concrete shall be protected from damaging mechanical disturbance, heavy shock or excessive vibration. All finished surfaces shall be protected from damage caused by construction equipment, materials or methods and rain or running water.

9.8 Temperature & Shrinkage Cracks: Temperature and shrinkage cracks which develop prior to the final acceptance of the plant by the Owner shall be repaired and waterproofed as specified herein and other applicable parts of the Specifications.

10. TESTING

10.1 General: The Contractor shall keep a log identifying the exact locations of poured concrete represented by each test cylinder and shall furnish two copies of the test reports and logs to the Engineer as they become available.

10.2 All strength tests shall be performed by a reputable testing laboratory hired by the Contractor at his expense and approved by the Engineer. The costs of performing all strength tests as specified herein shall be borne by the Contractor and no extra compensation will be allowed.

10.3 Slump Tests: Slump tests will be performed when requested by the Resident Project Representative and shall conform to "Standard Method of Test for Slump of Portland Cement Concrete", ASTM C143.

10.4 Strength Tests: Test cylinders shall be taken by the Contractor as directed by the Resident Project Representative and shall be cured and tested in accordance with the "Standard Method of Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field", ASTM C31. Not less than three specimens shall be made for each 20 cubic yards of concrete or fraction thereof in each day's pour, except that in no case shall a given mix design be represented by less than five tests. In the event that three test cylinders are not considered sufficient to represent the work done, the Engineer may direct that extra cylinders be made. The standard age of test shall be 28 days, but 7-day tests and 14-day tests may be used provided that the relation between the 7-day, 14-day and 28-day strengths of the concrete is established in advance by test for the materials and proportions used and approved by the Engineer. If the Contractor desires, extra cylinders may be made and tested for the purpose of indicating sufficient concrete strength for form removal or other purposes. If the average of the strengths of the test cylinders fail to obtain the specified strength so as to justify doubt as to the quality of the conrete, further tests shall be made at the Contractor's expense, of the concrete in place to determine its fitness to remain in the structure. These test shall be performed in accordance with the "Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete", ASTM C42. The strength level of the concrete will be considered acceptable if the average of three, 28-day test strength results equal or exceed the

specified compressive strength and no individual tests fall below the specified compressive strength by more than 200 psi.

10.5 Air Content Tests: Air content tests may be requested by the Resident Project Representative at his discretion and shall conform to the "Standard Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method", ASTM C173 or the "Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method", ASTM C231. The Contractor shall provide all necessary equipment, materials, sampling, and testing.

11. CONCRETE CURB AND GUTTER

11.1 Concrete curb and gutter shall be poured on a base of aggregate, contiguous with the base for street paving. Forms shall be metal or sound, dressed lumber, straight, free from warp, of sufficient strength to resist springing during construction, and of a height equal to the full depth of the item to be constructed. The forms shall be thoroughly cleaned, well oiled, securely staked, braced, and held to the required line and grade. A template shall be used to achieve the proper curb and gutter cross section.

11.1.1 In lieu of the forming requirements specified in Paragraph 11.1, slip form methods may be used for placement of concrete curb, concrete gutter, curb and gutter, and paved ditch providing proper lines, grades, and typical sections are maintained.

11.2 Required reinforcement and tie bars shall be held in the designated position during the placing of concrete by bar chairs or other approved devices. Joints shall be constructed at intervals and locations shown on the plans or as directed by the Engineer.

11.3 Concrete shall be placed on the prepared and sprinkled subgrade, compacted and struck off to the required thickness. Concrete shall be tamped or vibrated sufficiently to eliminate all voids and to bring mortar to the top, after which the surface shall be finished smooth and even. All edges shall be rounded with an edging tool. Faces of curbs shall be rounded at the top and bottom, by means of an approved tool, to the radius shown. All curb and gutter will be given a light broom finish and shall be sprayed with a liquid membrane-forming compound or as specified by the Engineer.

11.4 After the concrete has set sufficiently, the forms shall be removed, and where necessary, the contractor shall backfill adjacent to the concrete with suitable material, compacted and finished in a satisfactory manner.

11.5 Crack Control Joints: When the concrete curb and gutter has cured sufficiently to allow saw cuts to be made without raveling, the contractor shall saw crack control joints. These shall be cut at intervals at 20 feet, or as directed by the Engineer. Sawing of the joints shall be considered as a part of the curb and gutter construction with no extra compensation provided. All sawed joints shall be sealed as specified above.

12. CONCRETE SIDEWALK

12.1 Concrete sidewalk shall be poured on an aggregate base.

12.2 Required reinforcement and tie bars shall be held in the designated position during the placing of concrete by bar chairs or other approved devices. Expansion joints shall be constructed at intervals and locations shown on the plans or as directed by the Engineer.

12.3 Concrete shall be placed on the prepared and sprinkled base, compacted and struck off to the required thickness. Concrete shall be tamped or vibrated sufficiently to eliminate all voids and to bring mortar to the top, after which the surface shall be finished smooth and even. All edges shall be rounded with an edging tool. Crack control joints shall be placed with a joint tool at intervals of not more than 4'-0".

Concrete sidewalks shall be given a light broom finish and shall be sprayed with a liquid membrane-forming compound or as specified by the Engineer.

12.4 After the concrete has set sufficiently, the forms shall be removed, and where necessary, the contractor shall backfill adjacent to the concrete with suitable material, compacted and finished in a satisfactory manner. All joints shall be filled with as specified above.

13. GROUT

13.1 General: This item includes furnishing, placing and finishing the grout at the various locations as required.

13.2 Materials: Materials are specified herein.

13.3 Proportioning & Mixing: Grout shall consist of a mixture of 1 part portland cement and 2 parts fine aggregate with a slump of three inches to five inches. The water-cement ratio shall be maintained at not more than 4½ gallons per bag of cement. The ingredients shall be mixed in accordance with the applicable portions of this Specification so as to produce a uniform mass of material.

13.4 Placing: Before placing grout, the concrete shall be thoroughly cleaned of all dust, dirt or other deleterious material and then shall be thoroughly wetted. Grout shall be placed in one continuous operation to the thickness shown on the plans with no construction joints allowed.

13.5 After the grout is placed, it shall be given a floated finish as specified in this Specification and shall be cured as specified under Section 9 of this Specification.

1. GENERAL

1.1 Description: The work of this section consists of furnishing and using materials and procedures for air-entrainment of and/or addition of chemical admixtures to concrete.

2. MATERIALS

2.1 Air-entrainment Admixtures: Air-entrainment shall be accomplished by the use of Type 1 Portland cement with the addition of an approved air-entrainment admixture or by the use of Type 1A Portland cement. Air-entrainment admixtures shall conform to "Standard Specifications for Air-Entraining Admixtures for Concrete", ASTM C260.

2.2 Water Reducing, Retarding, and Accelerating Admixtures: Water reducing, retarding, or accelerating admixtures, if permitted by the Owner, shall conform to "Standard Specifications for Chemical Admixtures for Concrete", ASTM C494.

2.3 Fly Ash: Fly ash may be allowed as an admixture in the concrete mix concrete mix provided the following requirements are satisfactorily addressed.

2.3.1 Its use is in strict accordance with ASTM C618, latest revision;

2.3.2 Fly ash shall be sampled and tested in accordance with ASTM C311, latest revision;

2.3.3 Prior to being approved for use, fly ash shall be tested in combination with the cement and aggregates proposed for use to ascertain its suitability with regard to water requirements, strength development, shrinkage, heat of hydration, and durability.

3. EXECUTION

3.1 Water Reducing, Retarding, and Accelerating Admixtures: Such admixtures may be used when such use is requested by the Contractor subject to review and approval by the Owner. For certain uses, the Owner reserves the right to require the use of a retardant or other admixtures for specific uses such as a retardant in extensive wall pours to assure elimination of cold joints or for other such purposes. No additional compensation will be allowed when such admixtures are used. However, when certain such admixtures are used, it will be allowable to reduce the cement content of the mix to a minimum of 5 ½ bags of cement per cubic yard of concrete, subject to the following conditions: A trial batch and test cylinders taken therefrom demonstrate that the mix will meet the strength, workability, slump, and durability requirements of the specified mix previously herein stated. The strength shall be determined from seven-day test cylinders from a trial batch utilizing the admixture and made using the aggregates selected for the job, to establish the correct proportions to give proper workability with the water-cement ratio specified. The seven-day test strength shall equal 95 percent of the specified minimum 28-day strength.

3.2 Air-entraining and chemical admixtures shall be charged into the mixer as a solution and shall be dispensed by an automatic dispenser or similar metering device. Powdered admixtures shall be weighed or measured by volume as recommended by the manufacturer. The accuracy of measurement by any admixture shall be within ± three percent.

3.3 Two or more admixtures may be used in the same concrete, provided such admixtures are added separately during the batching sequence and provided further that the admixtures used in that combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other. Addition of retarding admixtures shall not be significantly delayed after the addition of the cement.

3.4 The addition of calcium chloride to the mix will not be allowed.

GENERAL NOTES:

THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL LINE AND GRADE STAKES.

ALL UTILITY COMPANIES SHALL BE CONTACTED A MINIMUM OF 72 HOURS PRIOR TO BEGINNING CONSTRUCTION TO REQUEST MARKING OF THE LOCATIONS OF ALL BURIED UTILITY LINES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE EXACT LOCATION AND PRESERVATION OF ALL BURIED UTILITY LINES.

THE CONTRACTOR SHALL REMOVE, PRESERVE, AND RESET ALL FENCES, POSTS, CULVERTS, SIGNS, STREET MARKERS, MAILBOXES, AND THE LIKE WITHIN THE LIMITS OF THE PROPOSED IMPROVEMENTS. ALL COSTS ASSOCIATED WITH THIS WORK SHALL BE INCLUDED IN THE CONTRACTOR'S BID PRICE.

ALL CONSTRUCTION AND EXCAVATION ACTIVITIES SHALL BE CONFINED TO EASEMENTS, ROAD RIGHT-OF-WAYS, AND/OR WORK AREA LIMITS AS SHOWN ON THE DETAIL PLANS.

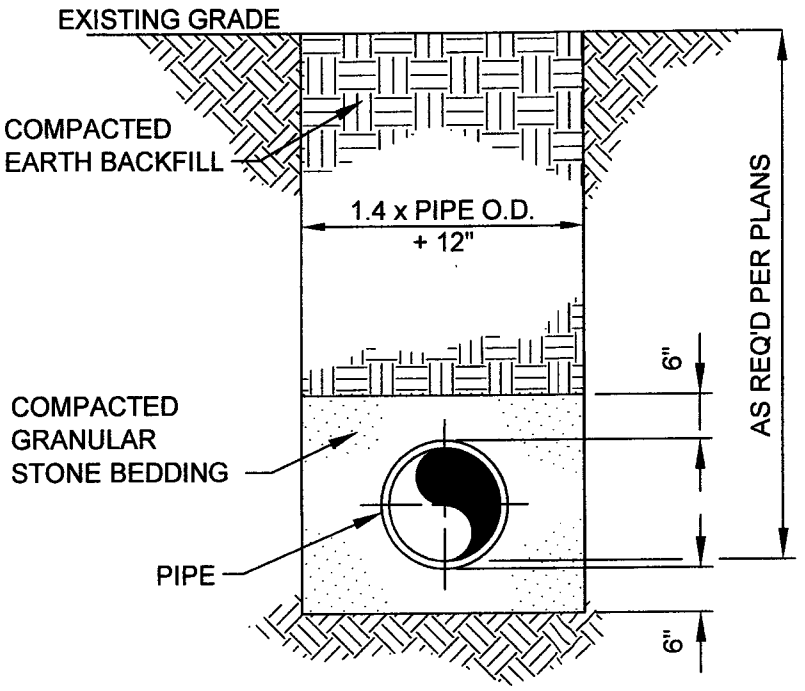
ALL TRAFFICWAYS, INCLUDING DRIVEWAYS, ALLEYWAYS, ETC., SHALL REMAIN ACCESSIBLE TO RESIDENTIAL AND EMERGENCY VEHICLES THROUGHOUT PROJECT DURATION.

EXISTING ASPHALT AND CONCRETE STREETS AND CURB AND GUTTER SHALL BE RESTORED TO MATCH ORIGINAL CONDITIONS PRIOR TO CONSTRUCTION.

ALL TRENCHES UNDER DRIVES AND STREETS SHALL BE BACKFILLED WITH GRANULAR STONE.

ALL AREAS DISTURBED BY CONSTRUCTION, NOT PAVED, SHALL BE TOPSOILED, FINISH GRADED, SEEDED AND MULCHED.

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
GENERAL NOTES	
REVISION NUMBER 0	DRAWING NUMBER SEW–1



NOTES:

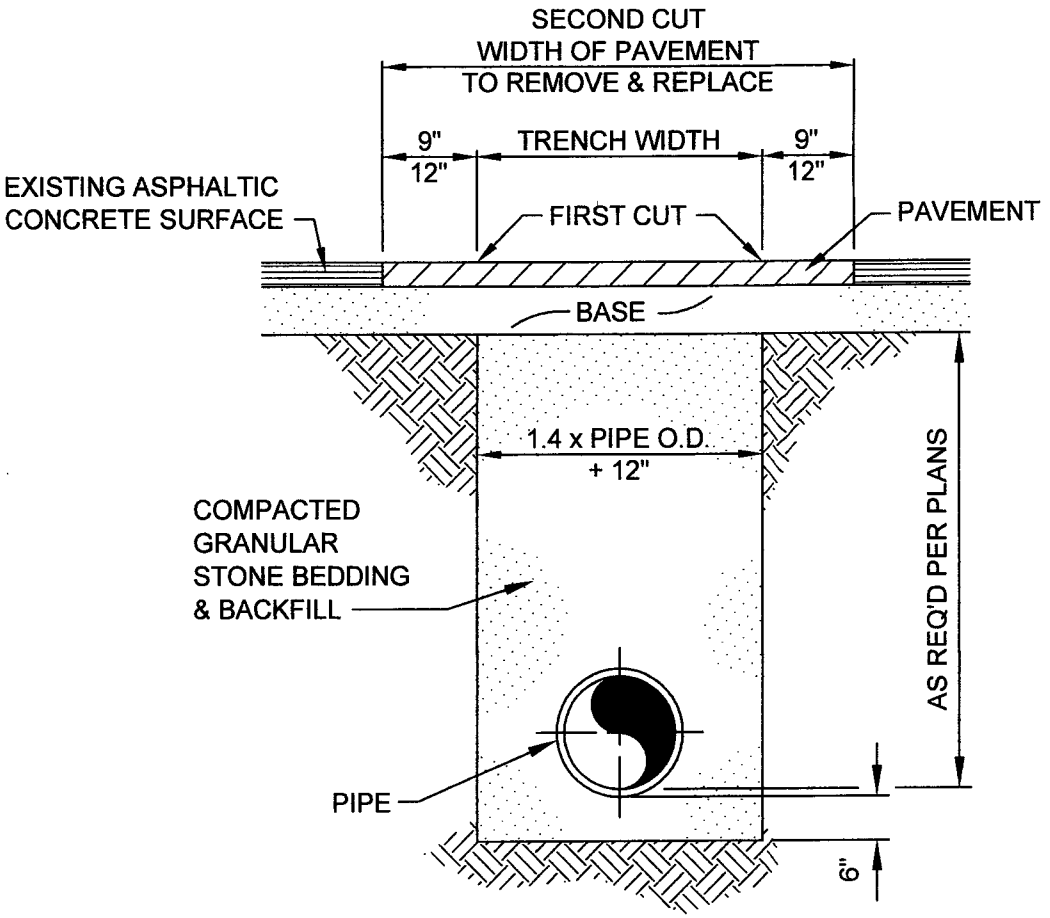
SEWERS SHALL BE TRENCHED, BEDDED AND BACKFILLED AS SHOWN.

DEPTH TO PRESSURE SEWERS SHALL BE 36" MIN. MEASURED FROM TOP OF PIPE TO FINISHED SURFACE.

TRENCH SHALL BE EXCAVATED TO PROVIDE VERTICAL WALLS.

TRENCH SHALL BE EXCAVATED TO A DEPTH OF 6" BELOW BOTTOM OF PIPE AND BACKFILLED TO 6" ABOVE PIPE WITH GRAVEL OR CRUSHED STONE CONFORMING TO THE SPECIFIED GRADATION TO PROVIDE UNIFORM BEDDING FOR THE ENTIRE LENGTH OF THE PIPE.

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
TRENCH & BEDDING	
REVISION NUMBER 0	DRAWING NUMBER SEW–2



NOTES:

SEWERS SHALL BE TRENCHED, BEDDED AND BACKFILLED AS SHOWN.

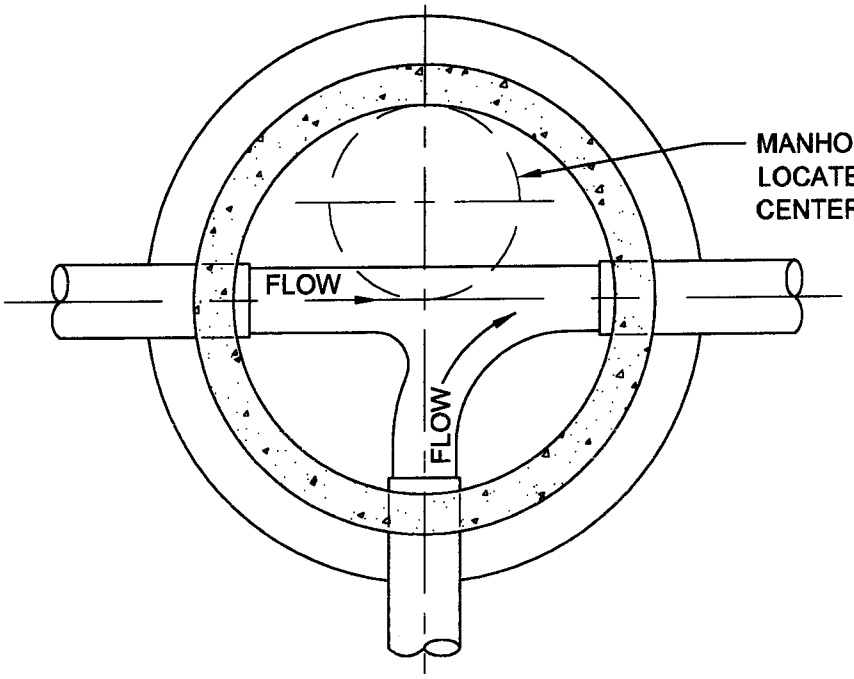
DEPTH TO PRESSURE SEWERS SHALL BE 36" MIN. MEASURED FROM TOP OF PIPE TO FINISHED SURFACE.

TRENCH SHALL BE EXCAVATED TO PROVIDE VERTICAL WALLS.

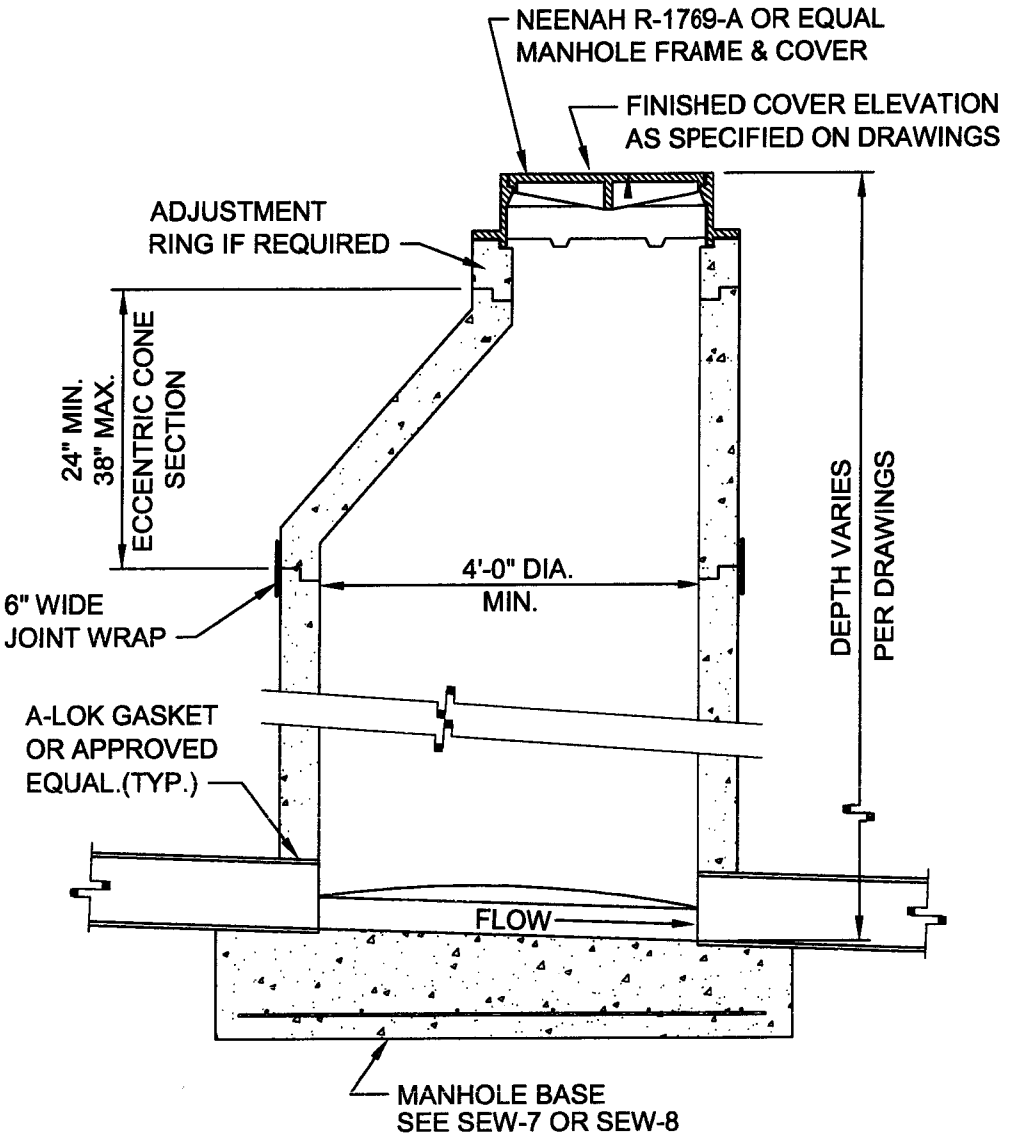
TRENCH SHALL BE EXCAVATED TO A DEPTH OF 6" BELOW BOTTOM OF PIPE AND BACKFILLED FULL TRENCH DEPTH WITH GRAVEL OR CRUSHED STONE CONFORMING TO THE SPECIFIED GRADATION TO PROVIDE UNIFORM BEDDING FOR THE ENTIRE LENGTH OF THE PIPE.

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
TRENCH & BEDDING (PAVEMENT)	
REVISION NUMBER 0	DRAWING NUMBER SEW-3

NOTES:
INVERTS COMING IN AT ELEVATION HIGHER THAN THE OUTLET INVERT SHALL BE FILLETED TO A UNIFORM SLOPE BETWEEN INLET AND OUTLET INVERTS.
INVERTS COMING INTO THE MANHOLE AT AN ANGLE WITH THE OUTLET PIPE SHALL BE CURVED INTO THE OUTLET CHANNEL.
FLOW CHANNEL THRU ALL MANHOLES SHALL CONFORM TO 1/2 THE INSIDE DIAMETER OF THE SEWER PIPE CROSS SECTION.
1/2 SECTION OF SEWER PIPE MAY BE USED ON STRAIGHT RUNS THRU MANHOLES FOR FLOW CHANNEL.



CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
MANHOLE PLAN	
REVISION NUMBER 1	DRAWING NUMBER SEW-4

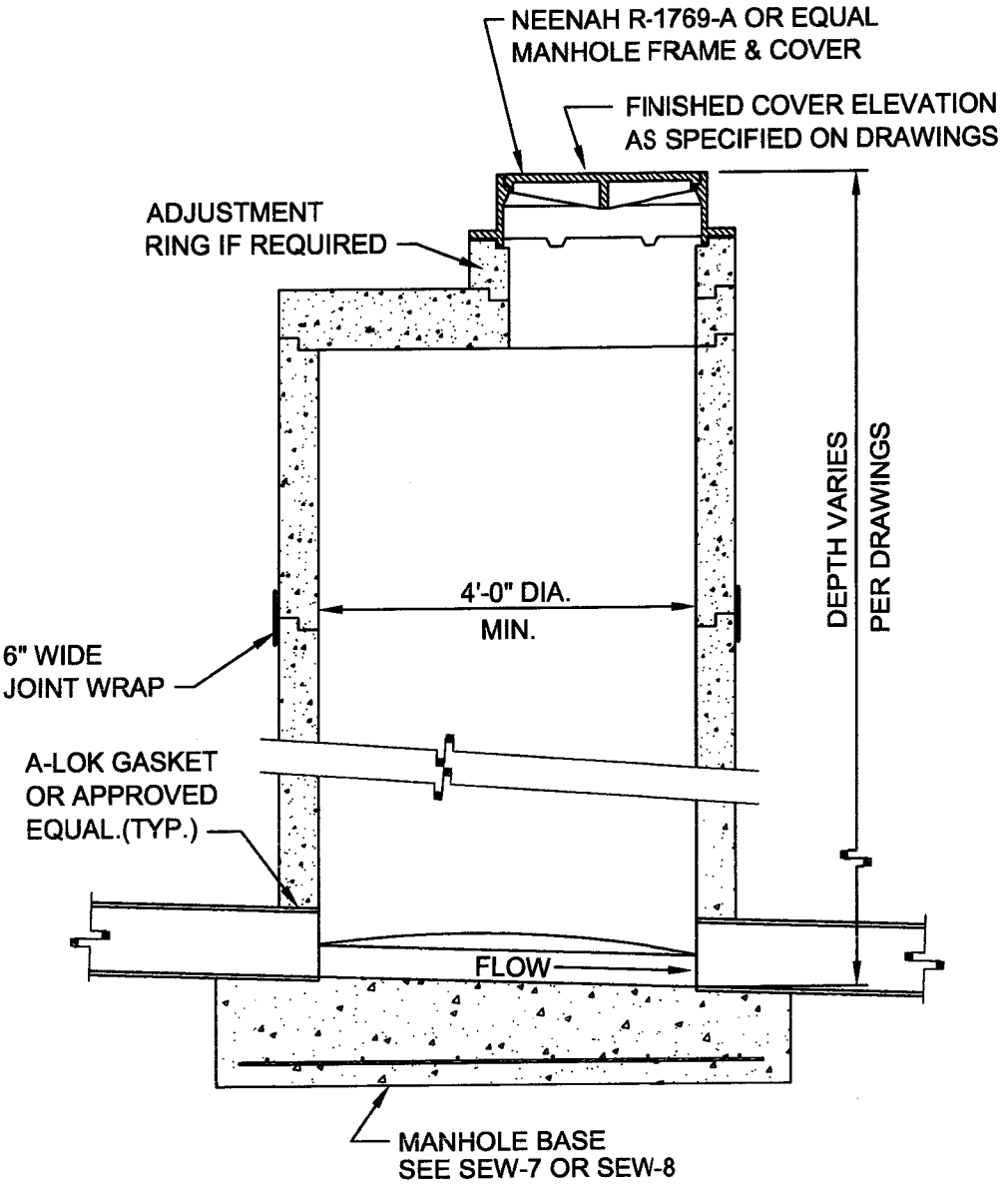


NOTES:

THIS DETAIL TYPICAL FOR ALL MANHOLES WITH DEPTHS OF 6'-0" AND GREATER.

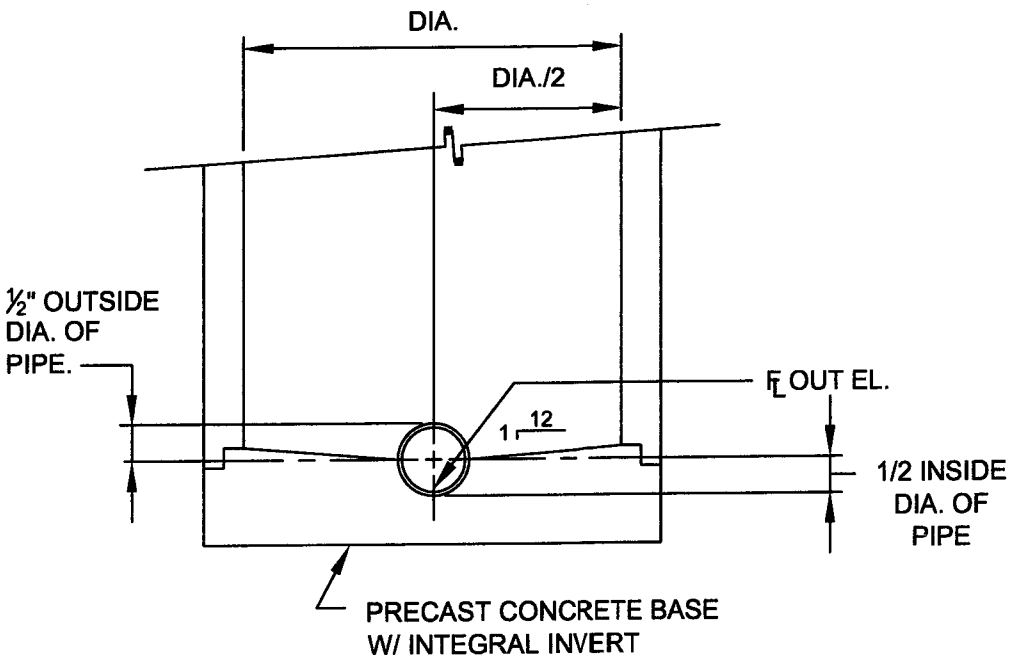
FOR MANHOLES WITH DEPTHS LESS THAN 6'-0" SEE SEW-6.

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
PRECAST MANHOLE (ECCENTRIC)	
REVISION NUMBER 1	DRAWING NUMBER SEW-5

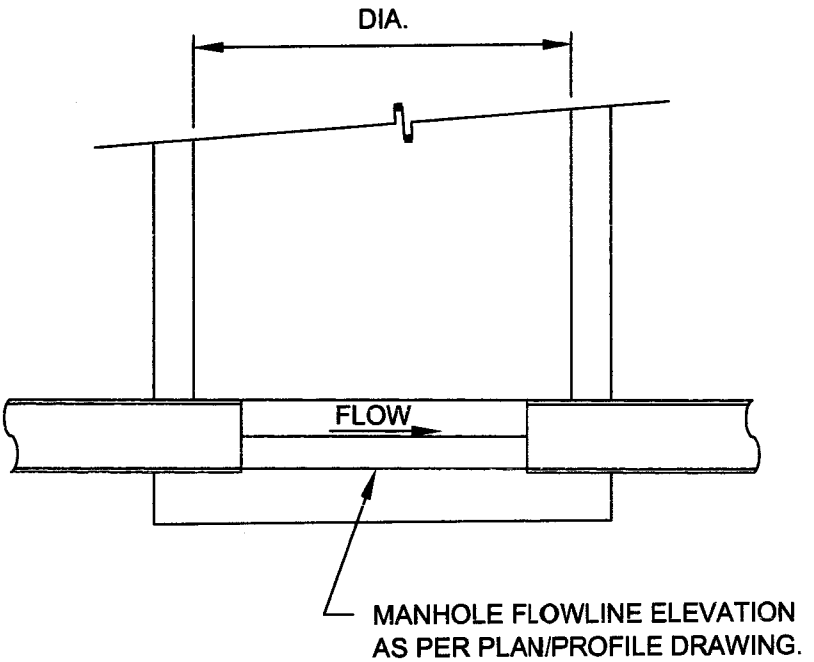


NOTES:
THIS DETAIL TYPICAL FOR ALL MANHOLES WITH DEPTHS OF 6'-0" AND LESS.
FOR MANHOLES WITH DEPTHS GREATER THAN 6'-0" SEE SEW-5.

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
PRECAST MANHOLE (FLATTOP)	
REVISION NUMBER 1	DRAWING NUMBER SEW-6

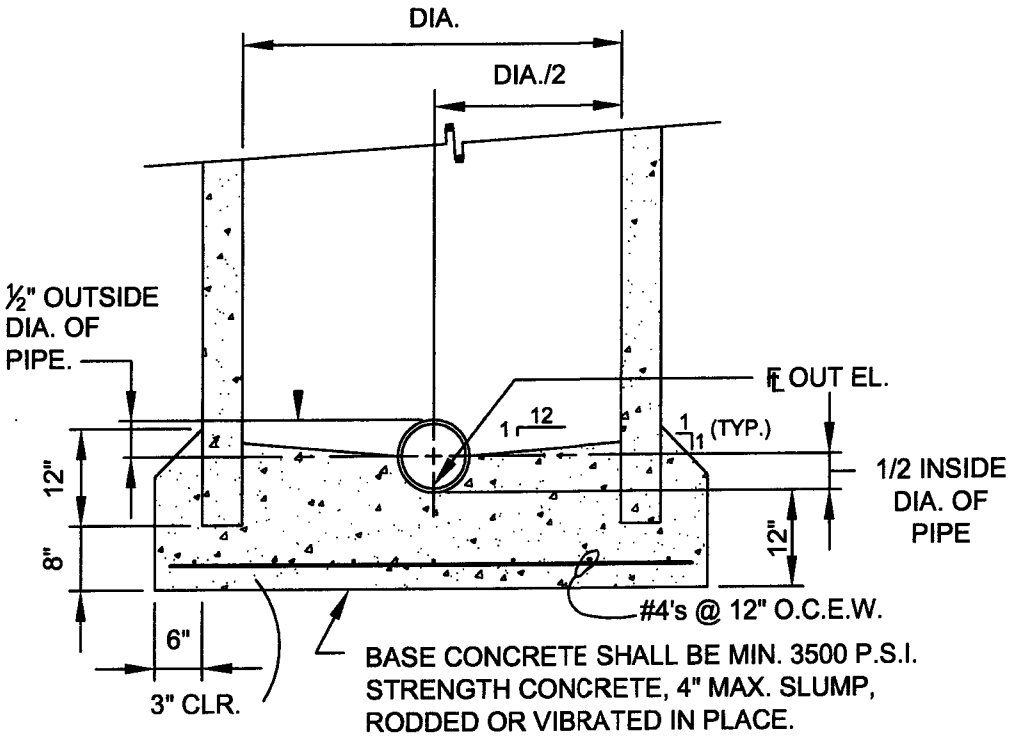


SECTION

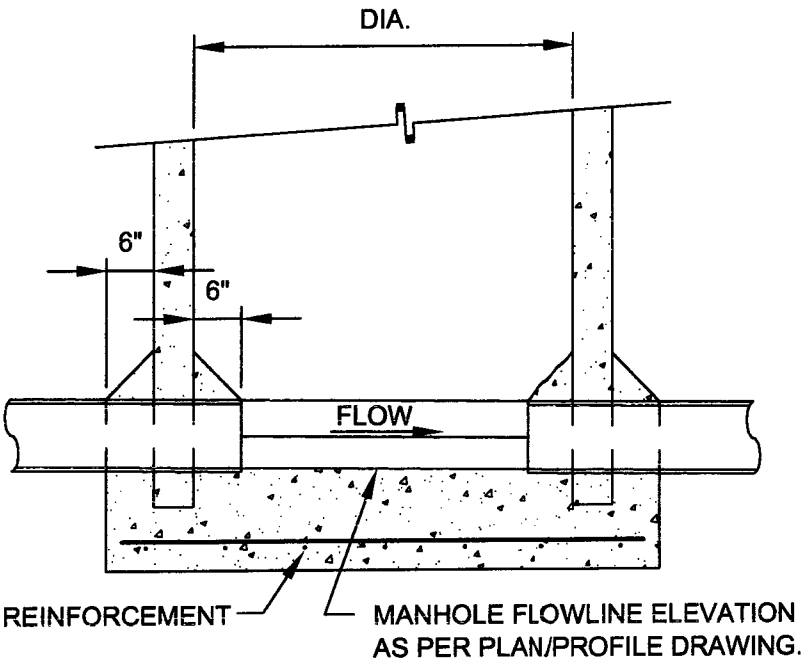


SECTION

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
MANHOLE BASE (PRECAST)	
REVISION NUMBER 1	DRAWING NUMBER SEW-7



SECTION



SECTION

CITY OF CARTHAGE

TYPICAL SEWER DETAIL

MANHOLE BASE (CAST-IN-PLACE)

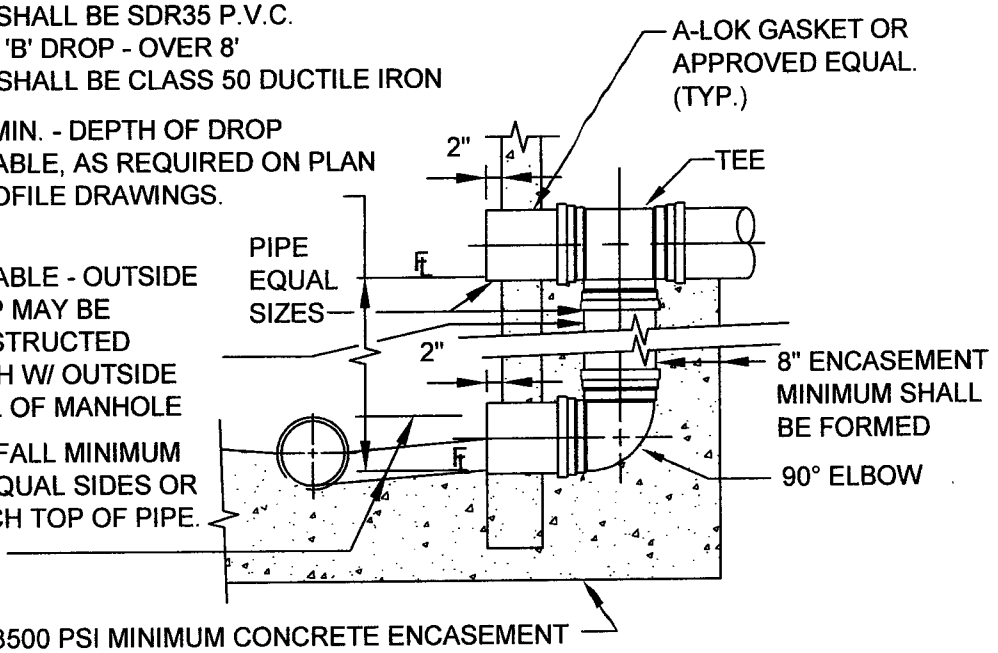
REVISION NUMBER	DRAWING NUMBER
1	SEW-8

NOTE:
TYPE 'A' DROP - 2' MIN.TO 8' MAX.,
PIPE SHALL BE SDR35 P.V.C.
TYPE 'B' DROP - OVER 8'
PIPE SHALL BE CLASS 50 DUCTILE IRON

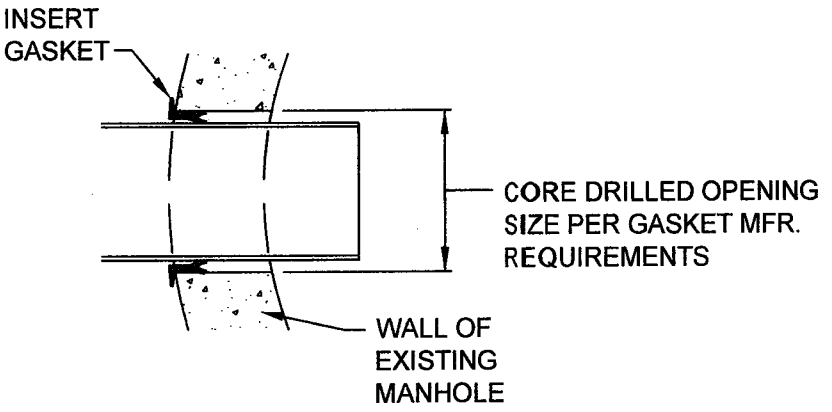
2'-0" MIN. - DEPTH OF DROP
VARIABLE, AS REQUIRED ON PLAN
& PROFILE DRAWINGS.

VARIABLE - OUTSIDE
DROP MAY BE
CONSTRUCTED
FLUSH W/ OUTSIDE
WALL OF MANHOLE

0.10' FALL MINIMUM
ON EQUAL SIDES OR
MATCH TOP OF PIPE.



CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
OUTSIDE DROP	
REVISION NUMBER 0	DRAWING NUMBER SEW-9

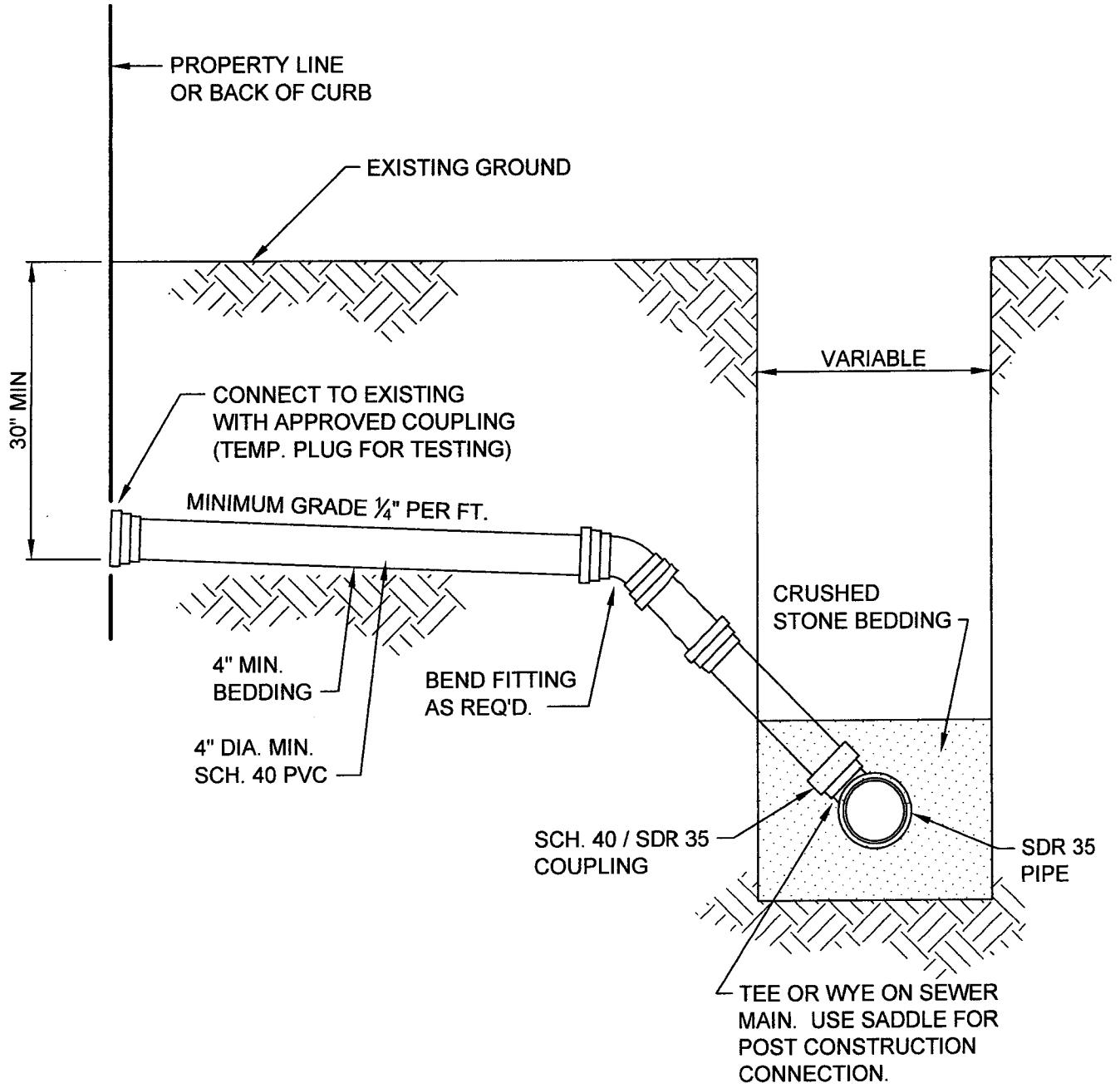


CITY OF CARTHAGE

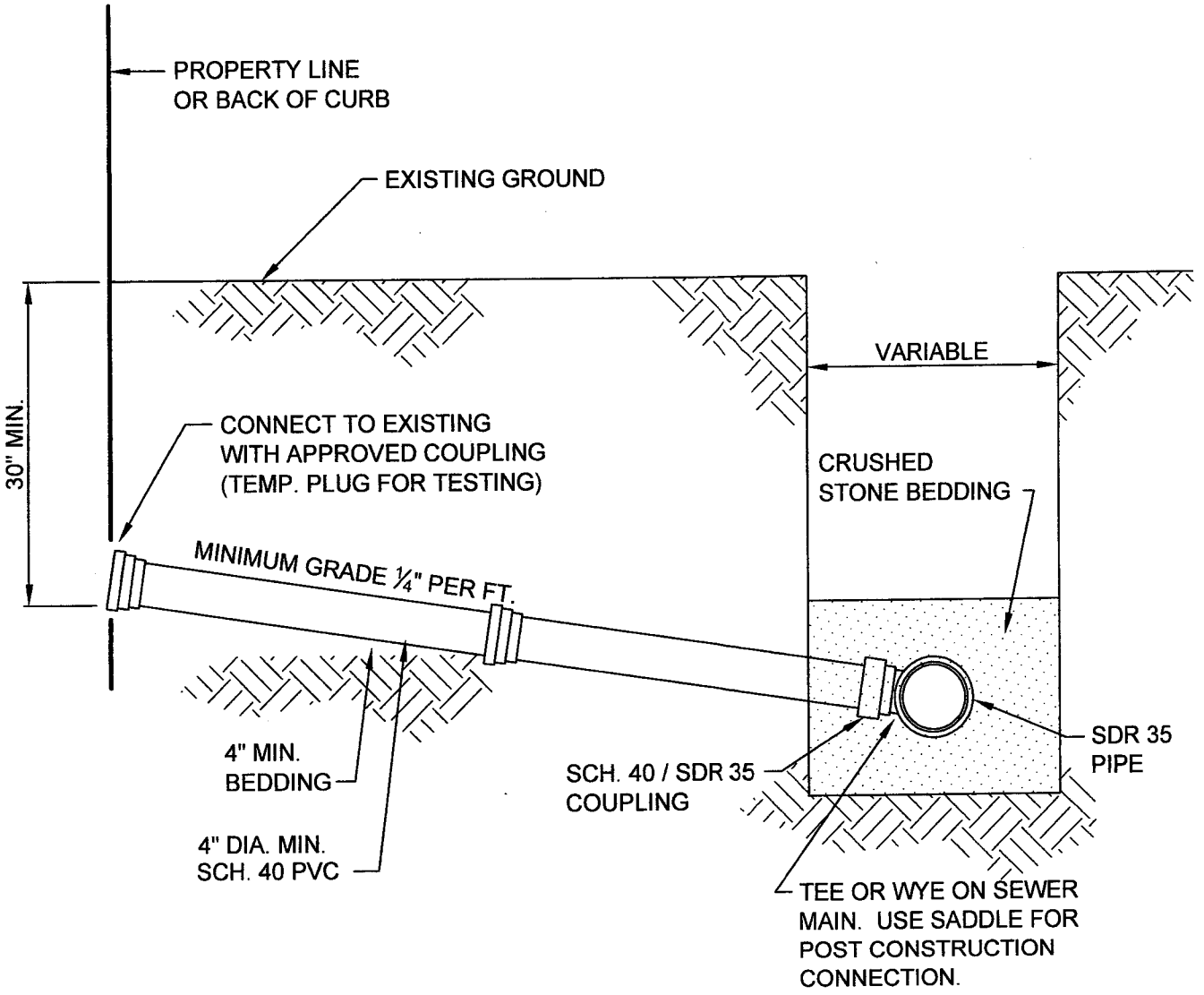
TYPICAL SEWER DETAIL

EXISTING MANHOLE CONNECTION

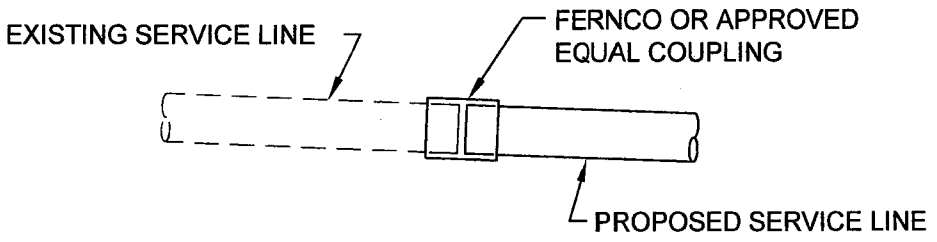
REVISION NUMBER	DRAWING NUMBER
0	SEW-10



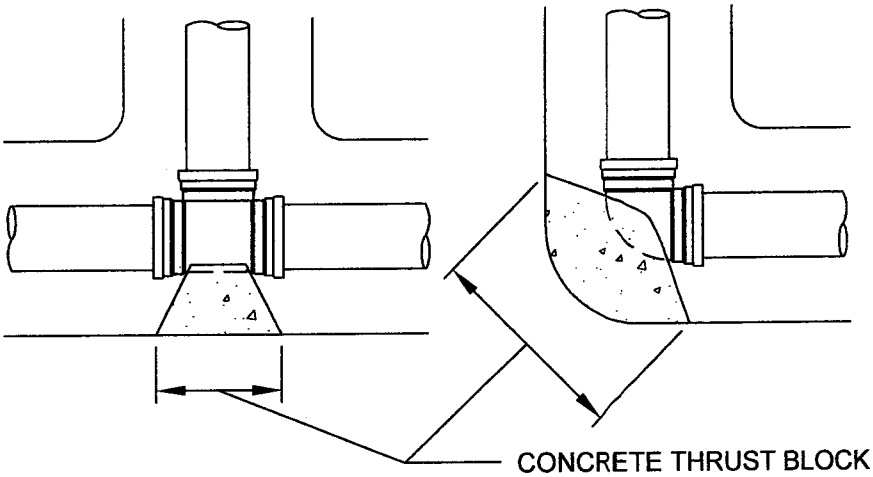
CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
SERVICE LATERAL (STACK)	
REVISION NUMBER 0	DRAWING NUMBER SEW–11



CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
SERVICE LATERAL (RUNOUT)	
REVISION NUMBER 0	DRAWING NUMBER SEW–12

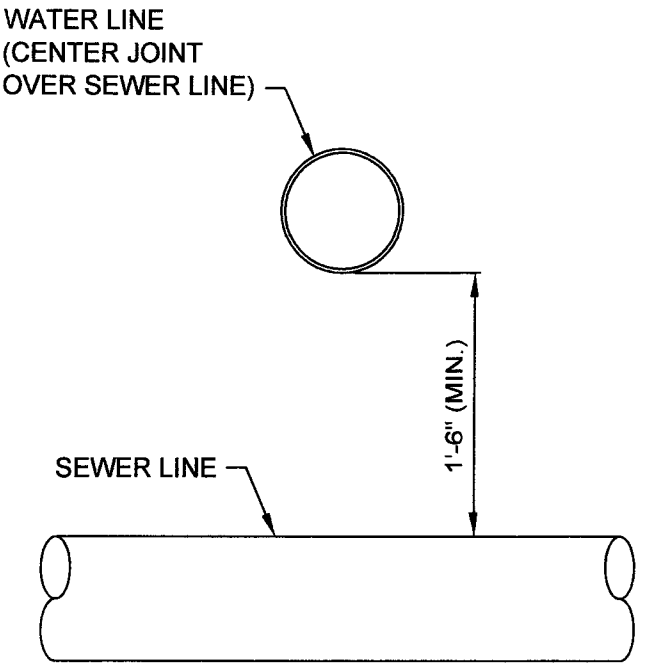


CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
SERVICE RECONNECTION	
REVISION NUMBER 0	DRAWING NUMBER SEW-13



NOTES:
THRUST BLOCKING SHALL BE 3000 P.S.I. MINIMUM CONCRETE.
REQUIRED BEARING AREA SHALL BE DETERMINED FOR EACH LOCATION.
THE CALCULATIONS SHALL UTILIZE AN ALLOWABLE SOIL BEARING CAPACITY OF 1000 P.S.F. AND A MINIMUM SAFETY FACTOR OF 1.5

CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
THRUST BLOCK	
REVISION NUMBER 0	DRAWING NUMBER SEW-14



CITY OF CARTHAGE	
TYPICAL SEWER DETAIL	
SEWER LINE CROSSING	
REVISION NUMBER 0	DRAWING NUMBER SEW-15