STATE OF MISSOURI
Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

July 9, 2015

CERTIFIED MAIL # 7012 2920 0002 0661 2901
RETURN RECEIPT REQUESTED

Skip Schaller, General Manager Utilities
City of Monett
217 5th Street
Monett, MO 65708-2310

RE: Approval for Monett, MO5010537,
Review No. 5053269-15

Dear Mr. Schaller:

We have completed the review of Standard Specifications for Water Main Construction dated April, 2015 from your engineer Anderson Engineering, Inc. for the City of Monett, Missouri. The proposed Standard Specifications meet the design standards as outlined in Chapter 8 of the "Minimum Design Standards for Missouri Community Water Systems" (effective December 10, 2013).

You may consider this letter approval of the Standard Specifications. Reference to these Standard Specifications should be included for future water main construction projects. If this office can be of any further assistance, feel free to give us a call.

Sincerely,

WATER PROTECTION PROGRAM

Maher Jaafari, P. E., Chief
Permits and Engineering Section
Public Drinking Water Branch

MJ:rmd

c: Kevin Sprenkle, P.E., Anderson Engineering, Inc.
Southwest Regional Office

File: CI
Monett, MO

STANDARD SPECIFICATIONS
FOR
WATER MAIN CONSTRUCTION

Presented by

The City of Monett
Monett, Missouri

Prepared by

Anderson Engineering, Inc.
CONSULTING ENGINEERS & SURVEYORS

218 5th Street, Monett, Missouri

April ~~2105~~ 2015 KRS

INDEX

WATER LINES

STRUCTURE EXCAVATION02220

1. GENERAL

1.1 Description: The work in this section consists of excavation, filling, compacting, and satisfactory disposal of all materials within the limits of the work required to complete structures in conformity with the dimensions as shown on the drawings and with established elevations and contours. there will be no distinction made between wet or dry materials below the surface of the earth. Structure excavation shall be considered as unclassified, which shall consist of all materials of whatever character encountered in the work, including soil, solid rock, fragmented rock, water, or other.

2. COMMON EXCAVATION

2.1 Excavation: The Contractor shall excavate to the lines, grades, and elevations shown on the drawings all materials within the work area and place and/or dispose of the excavated materials as specified herein, as called for on the drawings or as directed by the Owner.

2.1.1 Foundations: All footings shall be founded on firm undisturbed soil or fill concrete.

2.1.2 Slabs on Grade: Where the drawings show compacted granular backfill under basement slabs or other slabs on grade, the excavation shall be carried deep enough to permit the minimum thickness of compacted granular material to be placed.

2.1.3 Over-Excavation: In no case shall any footings be founded above those elevations shown on the drawings. If soft or unsuitable soil is encountered at elevations where footings are to be founded, the excavation shall be taken through unsuitable material and brought back up to grade with fill concrete. Contractor shall notify the Owner when such conditions are encountered and prior to over-excavation of the unsuitable material, in order to be compensated. Compensation for the extra work shall be negotiated by the Owner and Contractor. Excavations carried below depths shown on the drawings, without prior notification being given the Owner, shall be brought to grade with fill concrete at the Contractor's expense.

2.2 Side Forms: Unless the utilization of earth as a side form for footings is requested by the contractor in writing and approved by the Owner, side forms shall be required for all footings, grade beams, walls, and base slabs below grade. The excavation shall be large enough to allow for installation and removal of forms. In the cases where earth side forms are allowed, additional concrete thickness shall be utilized as directed by the Owner.

2.3 Excavation Bottom: Special care shall be taken to prevent disturbance of the bottom of excavations where the soil is to provide bearing for slabs, footings, etc. If surface water or other conditions which may decrease the bearing capacity of the foundation subgrade are present, then soil adequate to protect the foundation subgrade shall not be excavated until just before reinforcing steel and concrete are to be placed. The bottom of all excavations shall be inspected and approved by the Owner before the placement of any granular material, reinforcing steel, or concrete.

2.4 Borrow Excavation: When required, borrow excavation shall be the responsibility of the Contractor.

2.4.1 Borrow Characteristics: The soil to be utilized in construction of the earthen fill or backfill shall be an inorganic, low-plasticity clay containing from a trace to thirty percent chert fragments, and generally containing rocks no larger than 4-inches in its largest dimension.

2.5 Removal of Water: The Contractor shall at all times during the construction of the work provide and maintain ample equipment to remove and dispose of all water entering the excavations or other parts of the work, and keep said excavations dry until the structures to be built therein are completed. No reinforcing steel shall be placed in water, and no water shall be allowed to rise over any reinforcing steel

before the concrete has been placed. No water shall be allowed to come in contact with any concrete within 24 hours after placing unless specifically required by the drawings, or specified herein. The Contractor shall be held responsible for the conditions of any sewers, drains, or other conduits, or pipelines which may be used for drainage purposes, and such pipes or conduits shall be clean and free from all sediment before acceptance by the Owner.

2.6 Sheeting, Shoring, or Bracing: Sheeting, shoring, or bracing shall be placed by the Contractor wherever 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 shall be 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 his own expense, shore up, protect, and insure from injury all buildings, retaining 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 and insure the safety of workman and shall be as required by applicable federal, state, and local laws, rules, and regulations.

3. BACKFILL AND COMPACTION

3.1 Cuts: When required on the drawings, the soil below grade in cut sections shall be scarified, broken up, adjusted to a moisture content within the designated moisture range and compacted to 95% maximum density as determined by Section 02250 - COMPACTION CONTROL AND TESTING. When the depth of compaction in cut sections is shown on the drawings to be more than six inches, all material shall be removed to within six inches of the lower limit of the compaction. The layer of material left in place shall be scarified, broken up, adjusted to a moisture content within the designated moisture range, and compacted to 95% maximum density as determined by Section 02250 - COMPACTION CONTROL AND TESTING. This process shall be repeated until the cut section has been compacted to the grade shown on the drawings. Compaction of low plasticity or non-plastic fine grained materials shall be considered adequate when additional passes of the roller do not bring the tamping feet closer to the surface of the lift, provided the entire weight of the roller is supported on the tamping feet and none by material directly in contact with the drum. Sand and gravel which cannot be compacted satisfactorily with a sheepsfoot roller shall be rolled with a pneumatic-tired roller or other approved types. Each lift shall be rolled until no further consolidation is visually evident.

3.2 Around and Beneath Structures - General:

3.2.1 Prior to placing fill material, all topsoil and soft material shall be removed to a depth necessary to establish good bearing of the fill material. The surface of the ground shall be scarified to a depth of six inches and the moisture content of the loosened material shall be such that it will readily bond with the first layer of fill material.

3.2.2 When the drawings require the placement of fill beneath a proposed structure, the floor or footing subgrade shall be made with finely divided material sufficiently moist to compact readily when tamped. Fine grained material used as backfill shall be placed in six-inch compacted lifts and compacted to 95% maximum density as determined by Section in eight-inch lifts (compacted) and compacted to 100% of the maximum density as determined by Section 02250 - COMPACTION CONTROL AND TESTING.

3.2.3 Fill around and between structures shall be constructed, to as great an extent as possible, with earth obtained from the excavations for structures. The fill shall be compacted to Range "C" requirements as determined by Section 02250 - COMPACTION CONTROL AND TESTING.

TRENCHING, BACKFILLING, AND COMPACTING ..... .02221

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 be considered as unclassified, which 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 subgrades, 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 subgrade.

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.

3. TRENCHING

3.1 Lines and Grades: The Contractor shall furnish and set all stakes for the lines and grades as shown on the drawings including all grade boards, uprights, and accessory materials required. Grade boards shall be installed across the trench at t 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.

3.1.1 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 manhole and at 25 feet, 50 feet, 100 feet, and then 100-foot increments thereafter, upgrade of the manhole. 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.

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 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 and pipes 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: Even though all excavation shall be considered unclassified for pay purposes, 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 water main. 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 select material or 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 regrade 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.

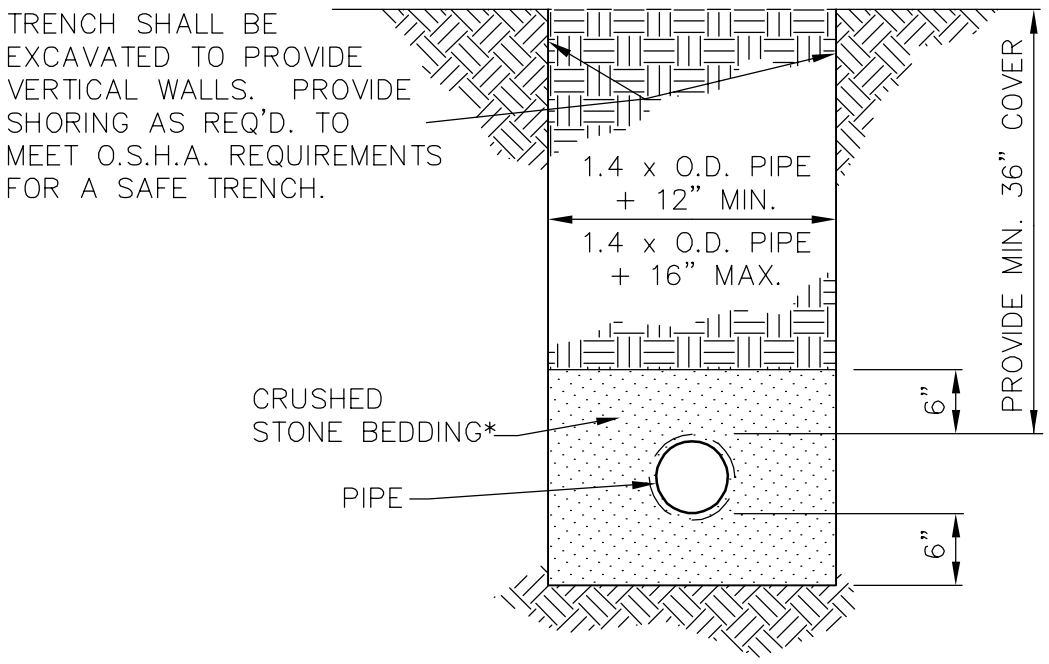
4.1.1 The Contractor may be required to settle certain backfill material with water, in addition to other backfilling procedures. The water will be furnished by the Contractor without cost to the Owner. Methods and procedures in using the water shall be approved by the Owner prior to carrying out the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

4.2 Roadway Crossings: At all open-cut roadway crossing, and as noted elsewhere, the trench shall be backfilled to grade with granular stone meeting the requirements of Section 0222 - GRANULAR STONE BEDDING AND BACKFILL. For roadway surface replacement, see Section 02575 - ROADWAY SURFACE REPLACEMENT.

4.3 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.



*NOTE: NOT REQUIRED WITH D.I.P. UNLESS SOLID ROCK

City of Monett, MO
Std. Spec. WATERLINE TRENCH & BEDDING

GRANULAR STONE BEDDING AND BACKFILL..... 02222

1. GENERAL

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

2. MATERIALS

2.1 Pipe Bedding: Aggregate shall be well-graded crushed stone conforming to ASTM Designation C33, Gradation 67, 1-inch to No. 8 as follows. Sand or chat may be allowed.

Laboratory Sieve	Amounts Finer than Weight %
1"	100
3/4"	90 - 100
3/8"	20 - 55
No. 4	0 - 10
No. 8	0 – 5

2.2 Select Material Bedding: Select material bedding consisting of native soil excavated from the trench, free of rocks, foreign material and frozen earth may be utilized for pipe bedding in areas outside of the street pavement and curb and guttering. The select material bedding shall be performed in accordance with AWWA C150, Type 3, Standard laying Conditions, or as approved by the city.

2.3 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 bedding shall be utilized for all street crossings. 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.

GRANULAR STONE BASE 02223

1. GENERAL

1.1 The work shall consist of furnishing and placing one or more courses of aggregate on a prepared subgrade as a part of roadway surface replacement in accordance with these specifications and in conformity with the lines, grades, thicknesses, and typical details shown on the plans.

2. MATERIALS

2.1 Granular Stone Base: Crushed stone shall conform to material specified as Type 1 aggregate by the Missouri Highway Department and produced by an approved source. Aggregate shall be mechanically crushed limestone or dolomite, graded to the following gradation ranges:

Amount by Weight Passing On:

1 Inch Sieve	100%
1/2 Inch Sieve	60-90%
No. 4	40-60%
No. 40	15-35%

Plasticity Index, not greater than 6 for material passing No. 40 sieve.

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

3. METHODS

3.1 Subgrade: All work on that portion of the subgrade 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 subgrade.

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. 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 (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 as outlined in Section 02250 - COMPACTION CONTROL AND TESTING.

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 Requirement: 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, experienced 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 (frontend loader, etc.). Magazines shall not be provided with artificial heat or 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 shall consist of furnishing all equipment, labor, materials, and incidentals to compact the various backfills. The Contractor shall be responsible for providing all necessary on-site testing facilities and equipment.

2. EXECUTION

2.1 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.

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

2.3 Compaction Requirements: Compaction requirements for soils as controlled by methods of testing described herein shall be as follows:

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

Range B -In-place compacted density shall be equal to or greater than ninety (90) percent of the maximum density at optimum moisture content.

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

Density range shall be Range B or as stated on the drawings. Compaction requirements for granular stone or sand, as controlled by methods of testing described herein, shall be to a density of not less that eight (80) percent of maximum density.

2.4 Moisture Content Requirements: The moisture content requirements as determined under the methods of testing described herein shall be as follows:

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.

2.5 Moisture Content Control:

2.5.1 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 truck 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.

2.5.2 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 insure 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 on the compacted surface.

3. SOIL TESTING

3.1 Scope of Tests:

3.1.1 Borrow Areas: All areas selected to supply backfill and area fill materials requiring a specified compaction shall have moisture-density relationships determined by ASTM D698, latest revision, when the soil is initially excavated. In place density of compacted soil shall be tested in accordance with ASTM D2167, latest revision, to determine compliance with specifications. Specific testing locations will be determined by the Owner.

3.1.2 Granular Stone and Sand: Granular stone and sand shall have moisture-density relationships determined by ASTM D2049, latest revision. In place density shall be determined by ASTM D2167 OR ASTM D1556, latest revision.

3.1.3 Compacted Soil Sub-Base Supporting Concrete, Steel, or Masonry Structures: The number of density tests shall be a minimum of three per structure, or two per 100 ft2 of area for each two lifts of fill. In place density shall be as determined by ASTM D2167, latest revision.

3.1.4 Compacted Soil Sub-Base Supporting Rigid and Flexible Pavements and Crushed Stone Surfacing: The number of density tests shall be a minimum of three, or two per 300 S.Y. of area and for each 12 inches of fill, whichever is greatest.

3.1.5 Compacted Granular Stone or Sand Supporting Concrete, Steel, Masonry Structures, Rigid and Flexible Pavements: The number of density tests shall be a minimum of three per structure, or two per 300 S.Y. of area.

3.1.6 Compacted Trench Backfill over Granular Base: The Owner shall reserve the right to conduct density testing at a rate of one test per 100 L.F. of trench for each two lifts of fill. Density tests shall be performed as specified by ASTM D2167, latest revision. The costs of the initial density testing shall be borne by the Owner. Any retesting which is required as a result of a failure of the compacted backfill to meet the specified compaction requirements shall be paid for by the Contractor. Any area which fails to meet the specified compaction requirements shall be recompacted and retested until it meets the specified requirements.

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 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.

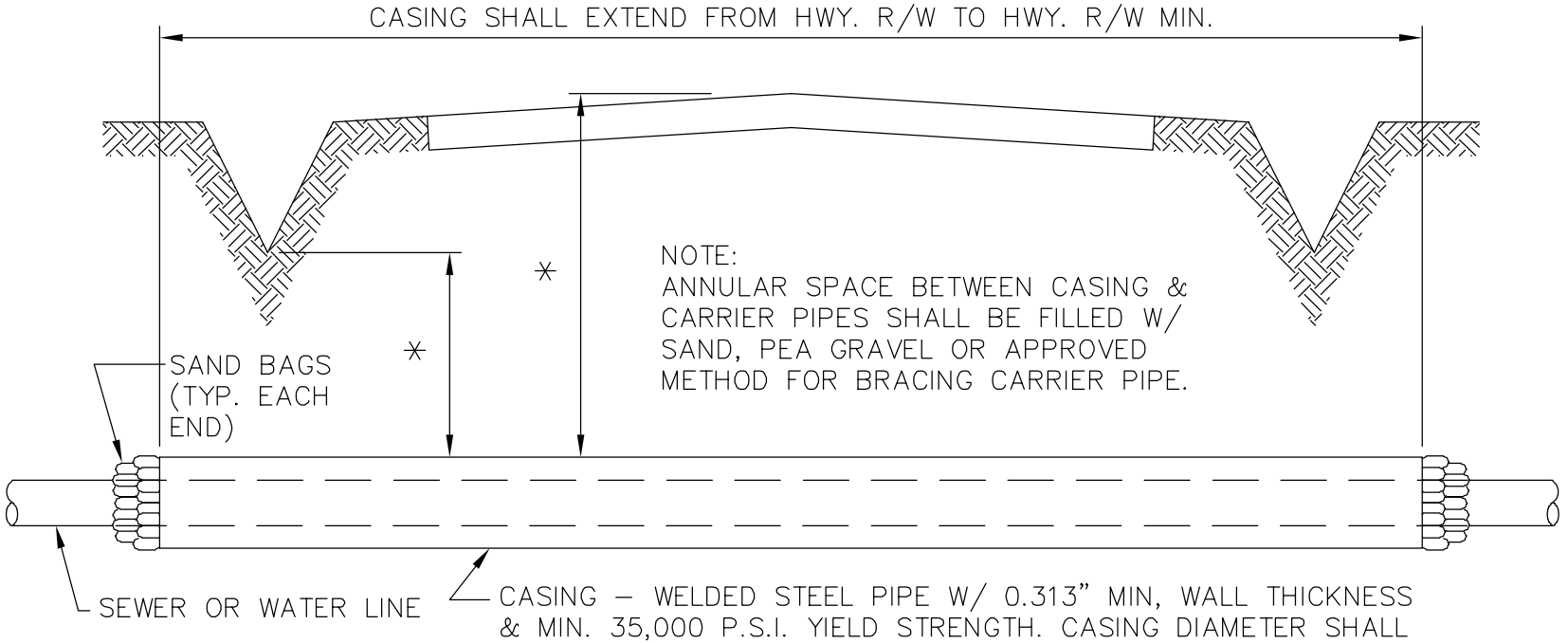
3. EXECUTION

3.1 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 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. Pipe spacers shall be used on carrier pipe.

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

3.3 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 Highway Department and acquire necessary permits and bonds. Where the Highway Department or railroad company 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.



City of Monett, Missouri
Std. Spec.
BORED OR TUNNEL
HIGHWAY CROSSING

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 landscaping as required herein, replacement of fences, stone-lined ditches, walls and embankments, and restoration of miscellaneous structures (mailboxes, street signs, etc.).

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 al the necessary materials to restore areas affected by construction to a condition equal to that which existed prior to construction. Areas requiring Type B surface restoration shall be so designated on the drawings.

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 require 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.

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, et., required to prevent interference with any work by water, ice or snow. Damage of any kind of 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 surfacings 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 Missouri Highway and Transportation Commission Standard Specifications for type BP-1 Plant Mix Bituminous Pavement as set forth in Section 401 of the Standard Specifications.

2.3 Crushed Stone Surfacing: Crushed stone base shall conform to material specified and shall be produced by an approved source. Aggregate shall be mechanically crushed limestone or dolomite. It 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 shale shall be uniformly distributed throughout the mass. The aggregates shall conform to the following gradation requirements when tested utilizing wet preparation techniques:

Percentage by Weight Passing Each Sieve:

1 inch Sieve.....100%
1/2 Inch Sieve ..... 60 - 90%
No. 4 ..... 40 - 60%
No. 40..... 15 - 35%

Plasticity Index of the fraction passing the No. 40 sieve shall not exceed 6. The crushed stone base shall be compacted to not less than 95% of maximum density at optimum moisture content as determined by Mod. AASHTO T-99.

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 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.

3.2.2.1 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.

3.2.2.2 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.

3.2.2.3 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.

3.2.2.4 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.

3.2.3.1 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.

3.2.3.2 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.

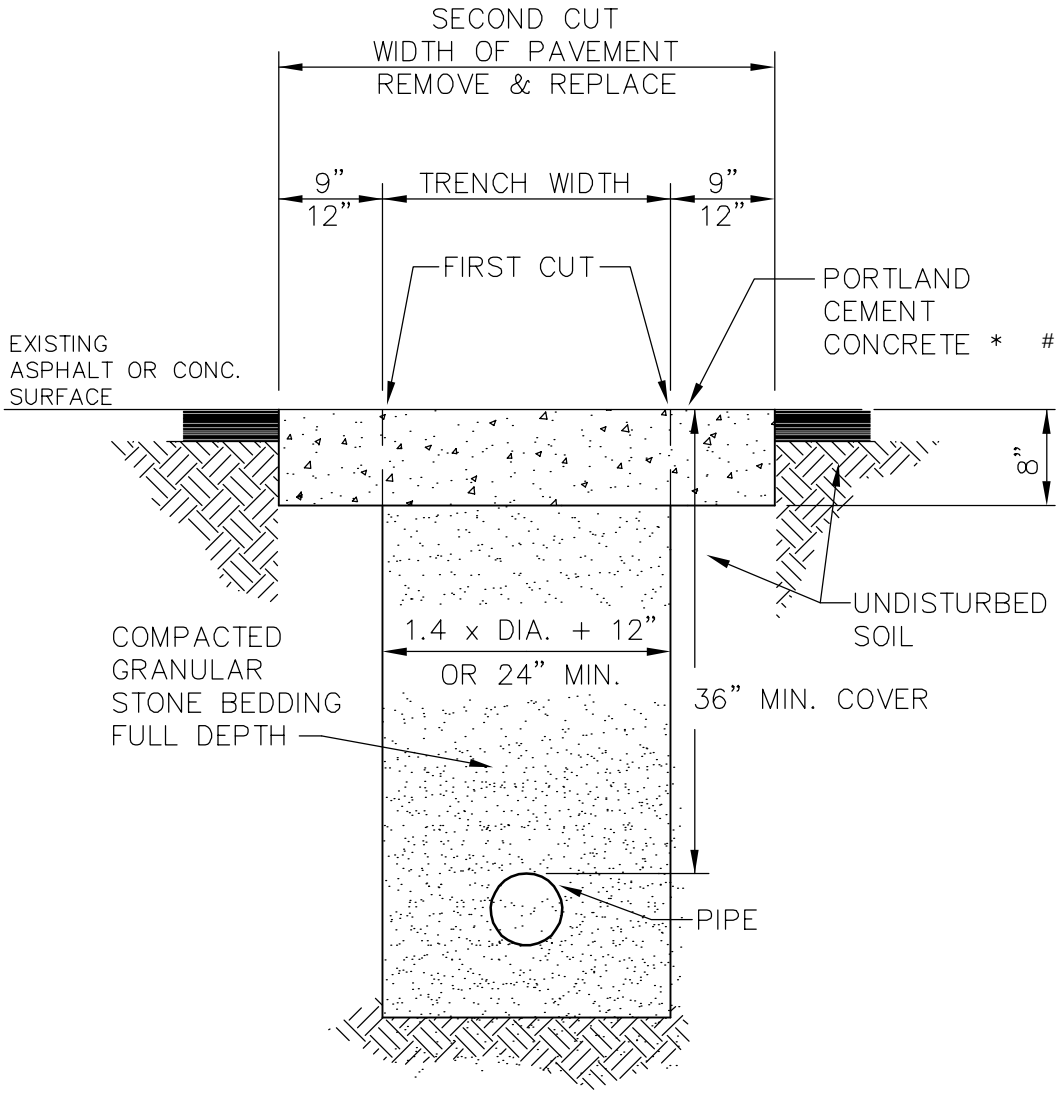
This stone shall be roller compacted from the sides to center with a steel wheeled roller weighing a minimum of five tons.

3.2.3.3 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.

3.2.3.4 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.

3.3 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.

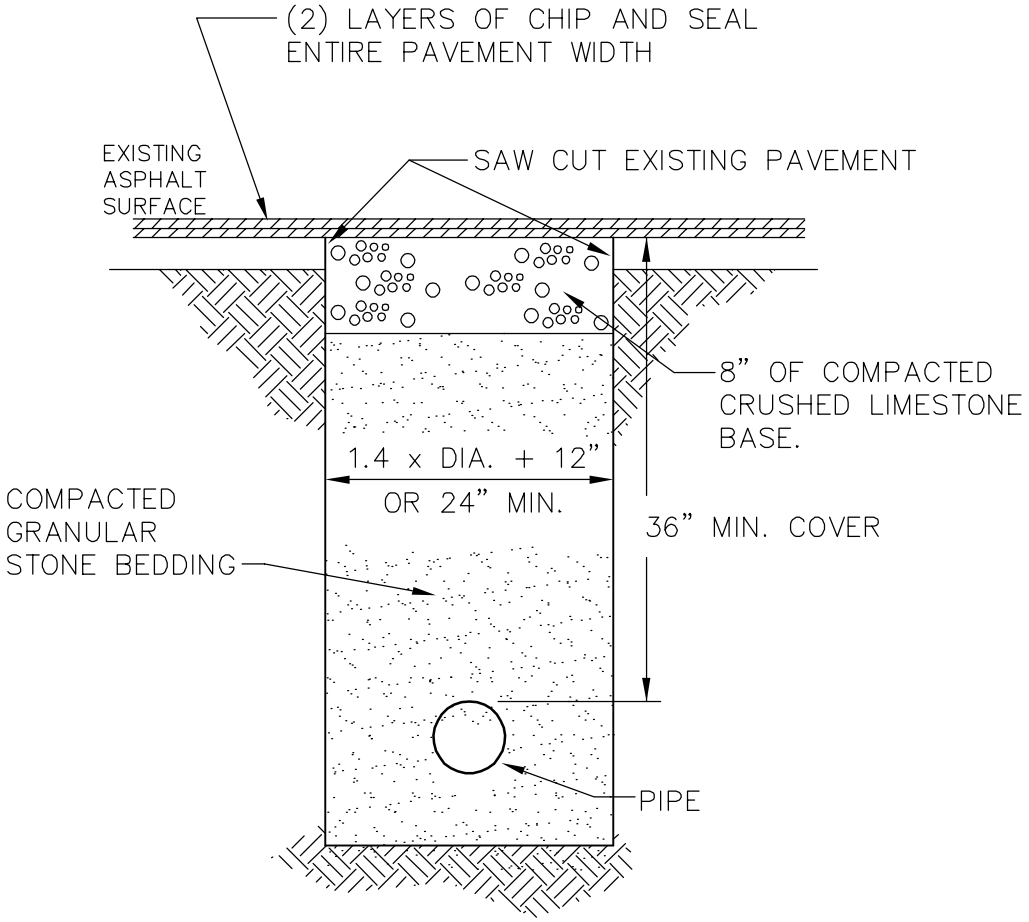


NOTE:
FIRST & SECOND CUTS OF EXISTING PAVEMENT SHALL BE SAW CUT FULL DEPTH.

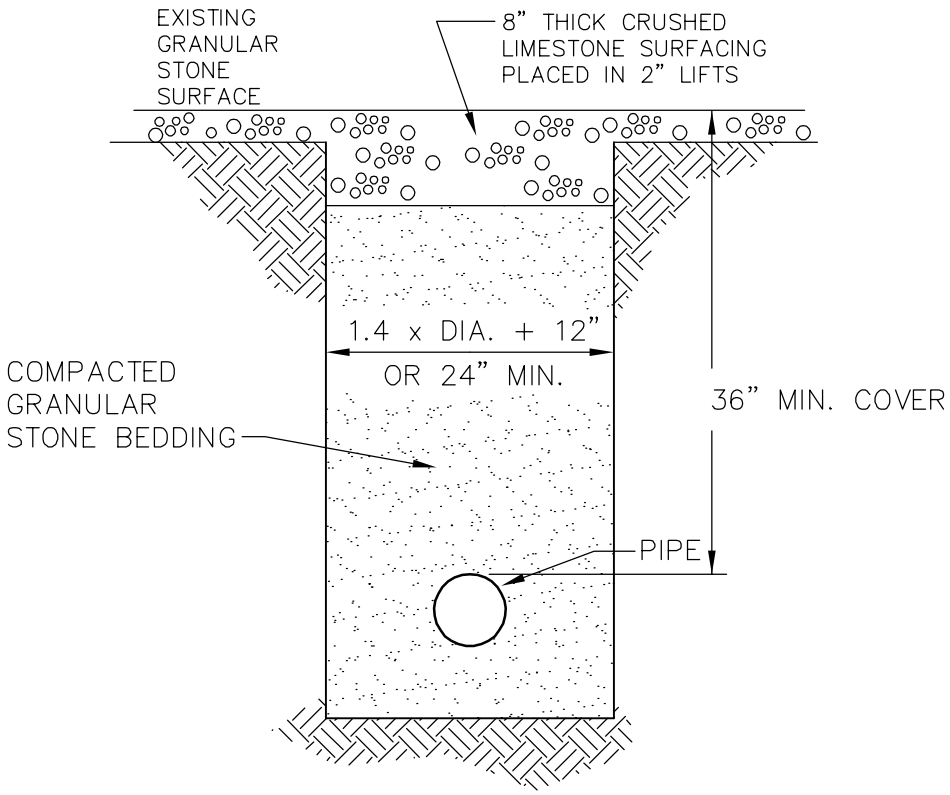
* FOR SIDEWALK REPAIR, CONCRETE SHALL BE 4" THICK.

\# Alternate Pavement Repair, 3" thick MoDOT BP1 over 6" thick compacted Type 1 Aggregate Base

City of Monett, Missouri
Std. Spec. PAVEMENT REPAIR PORTLAND CEMENT CONCRETE



City of Monett, MO
Std. Spec. PAVEMENT REPAIR CHIP & SEAL



City of Monett, MO

Std. Spec.

PAVEMENT REPAIR
CRUSHED STONE

DUCTILE IRON PIPE AND FITTINGS 02615

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 350 and shall conform to the latest revision of ANSI A21.51 – (AWWA C151) Standard for Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand Lined Molds, for Water or Other Liquids. The pipe shall be standard asphaltic varnish coated on the outside. Pipe shall be cement mortar lined in conformance with ANSI A21.4 – (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/A21.10. 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 350 unless noted otherwise on the drawings. Mechanical joint and push-on joint fittings shall meet all applicable requirements of ANSI/AWWA C111/A21.11.

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 - (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 250. 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 350 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.

2.3.4 Restrained Joint: The restrained joint for pipes 14-inch diameter and larger shall be a boltless connection type that utilizes a square, alloy steel, welded-on retained ring in conjunction with a split ring and socket groove to provide the means of restraint. The joint shall be disassembleable using a closure-spreader mechanism integral to the split ring. The split ring, retainer ring, and all parts associated with the closure-spreader mechanism shall be corrosion-resistant, high strength, low alloy (HSLA) steel conforming to ANSI/AWWA C111/A21.11. All required joint materials including neoprene gasket and lubricant shall be supplied with the pipe. Restrained joint shall be “Lok-Ring Joint Pipe” as manufactured by American Ductile Iron Pipe. As an alternate to the preceding, the restained joint may be TR-FLEX or TR-FLEX GRIPPER as manufactured by U.S. Pipe and Foundry Co., SUPER-LOCK as manufactured by Clow Corporation, or approved equal.

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.

GATE VALVES AND BOXES 02641

1. GENERAL

1.1 Description: The work in this section consists of furnishing, hauling, and placing the gate valves as shown on the plans and herein specified, and all labor, tools, and equipment necessary to install the valves.

2. MATERIALS

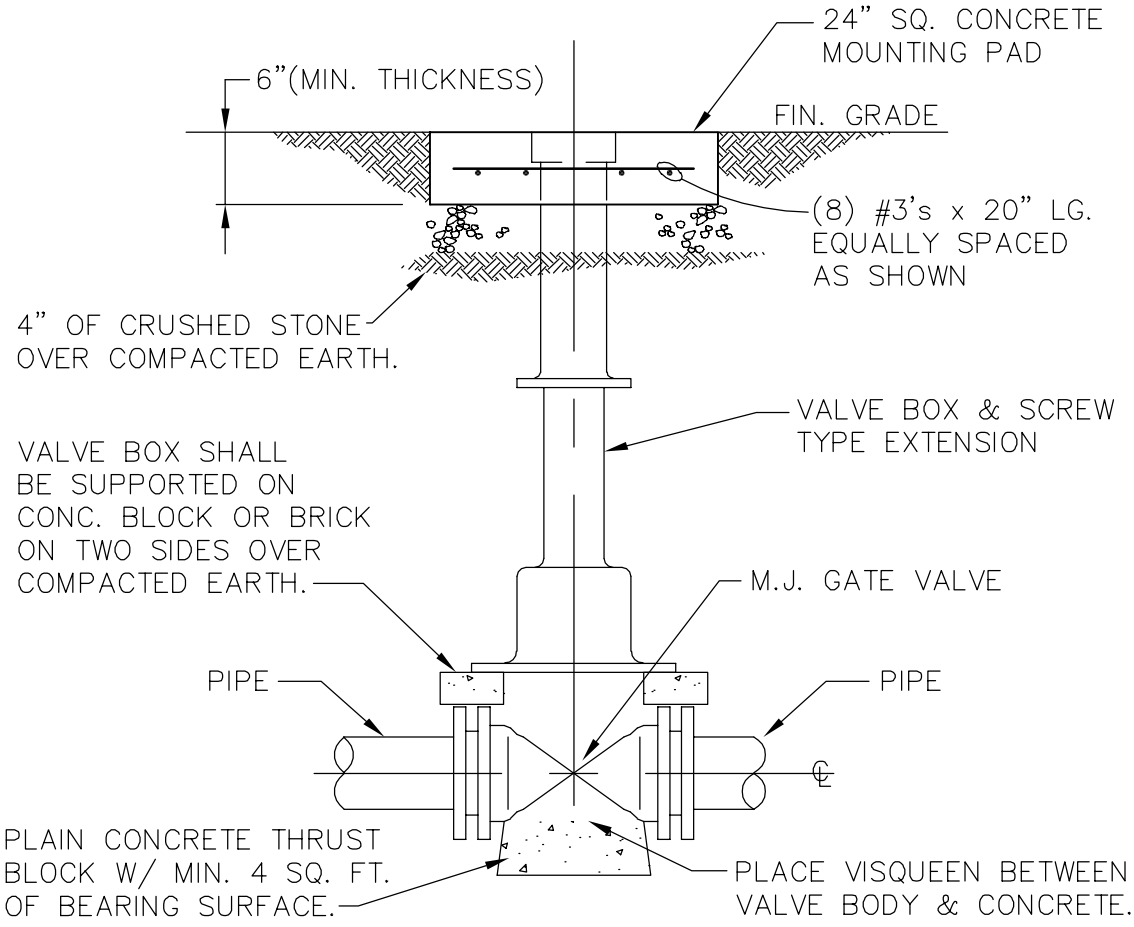
2.1 Valves: Gate valves shall be non-rising stem equipped with either handwheel operator or a two-inch square operating nut as indicated on the drawings.

2.2 End Connections: Shall be as indicated on the drawings.

2.3 Valve Boxes: Valve boxes shall be located as shown on the drawings. The valve box shall have a round top with open base and shall be provided with a top cover. The valve box shall be of a two-piece type with top piece capable of adjustment to final grade. Valve boxes for buried pipe shall be provided with a reinforced concrete pad at ground level.

3. EXECUTION

3.1 Installation: Each gate valve shall be installed at the locations and grades as shown on the plans. The Contractor shall insure that the valve is operating freely and that the valve box, if required, is properly placed to allow the use of the necessary tools for the operation of the valve and is plumb and centered over the operating nut on the valve. When buried, the tops of the valve boxes shall be level with the finish elevation of the ground. Valve storage, shipment, and installation shall strictly comply with ANSI/AWWA Standard C500.



City of Monett, Missouri
Std. Spec.
GATE VALVE

FIRE HYDRANTS AND APPURTENANCES 02644

1. GENERAL

1.1 Description: The work in this section consists of furnishing and installing the fire hydrants in the designated locations and to the lines and grades as shown on the plans and herein specified, and all tools, labor, equipment, materials, and incidentals necessary to complete this section.

2. MATERIALS

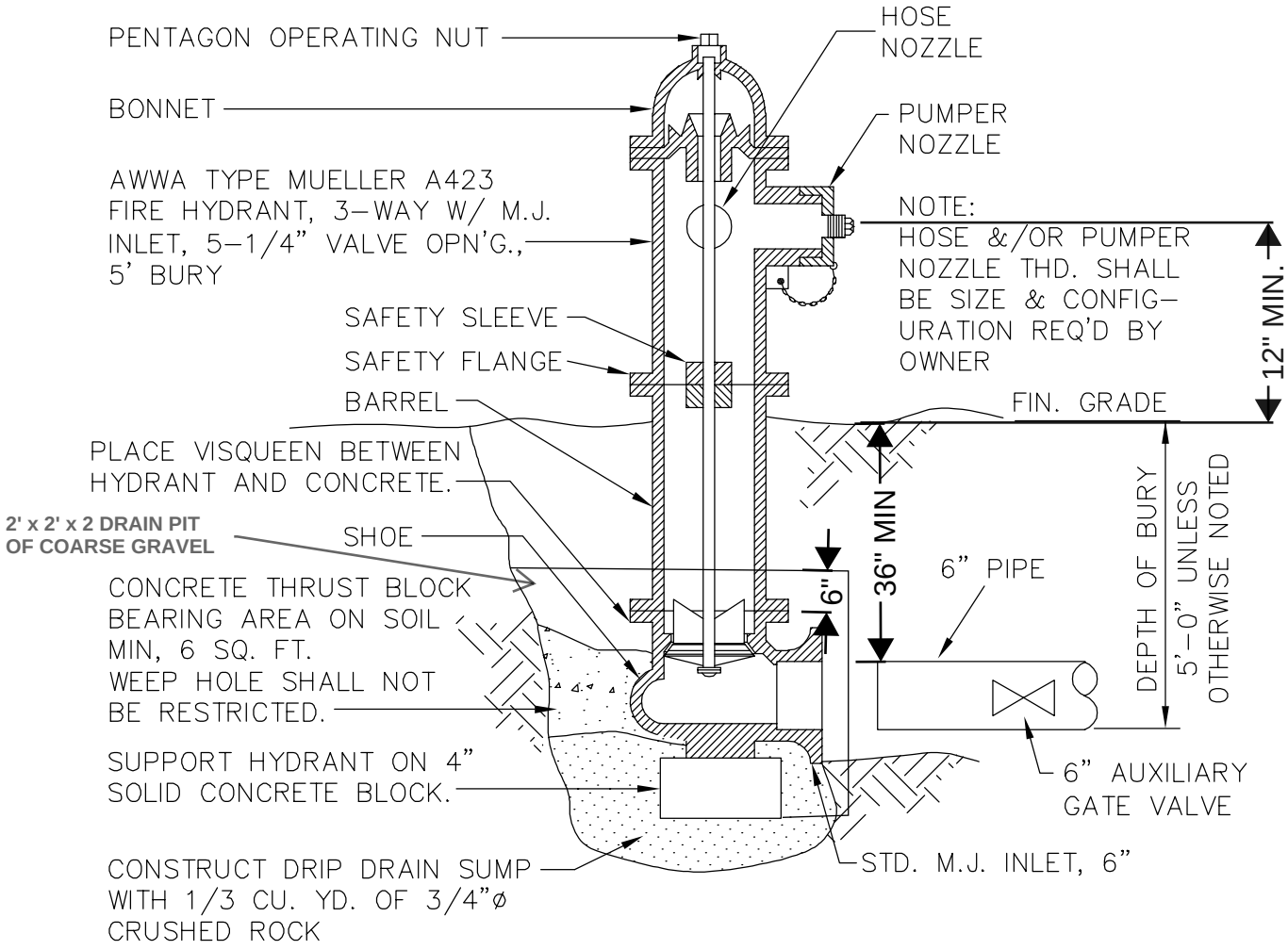
2.1 Fire Hydrant: Shall meet or exceed requirements set forth in AWWA Standard C502, latest revision. Fire hydrants where shown shall be 3-way, 6 inch traffic model fire hydrants with non-freezing, cast iron bodies, full bronze mounted, suitable for a working pressure of 200 PSI. Hydrants shall be Mueller No. A-423 with 5-inch steamer nozzle, 5 ¼ inch valve opening, 60-inch bury, and 6-inch MJ or approval equal. Each hydrant shall be given a 300 PSI hydrostatic test in the shop.

Hydrants are to be installed with thrust blocking to provide “blow-off” protection and prevent undue strain of the ductile iron pipe water main as shown on the plans.

The owner shall be furnished one (1) key wrench for each ten (10) hydrants.

3. EXECUTION

3.1 Installation: The fire hydrant shall be set plumb with the break off flange set at the finished surface. The fire hydrant shall have adequate blocking and drain materials installed. The Contractor shall insure that the fire hydrant drain valve is in proper working condition. The fire hydrant shall be disinfected.



City of Monett, MO
Std. Spec.
FIRE HYDRANT

Rev. 03/09/05

WATER SUPPLY PIPING SYSTEM..... 02713

1. GENERAL

1.1 Description: The work in this section consists of furnishing and installing all underground water supply piping, in the designated locations and to the lines and grades as shown on the plans and herein specified, and all tools, labor, equipment, materials, and incidentals necessary to complete this section.

1.2 All applicable work shall be done in accordance with the latest AWWA Specifications.

1.3 Where conflict may occur, the following specifications shall apply.

1.4 All water main extension or replacement projects shall be constructed in accordance with this specification and shall be a minimum of eight inches (8") in diameter DIP unless otherwise shown on the plans.

2. MATERIALS

2.1 Ductile Iron Pipe: All ductile iron water line piping and fittings six inches in diameter and larger shall be cement mortar lined ductile iron pipe with mechanical or push-on joints, meeting the specifications given in Section 02615 - DUCTILE IRON PIPE AND FITTINGS.

2.2 Polyvinyl Chloride Pipe and Fittings: All PVC pipe furnished shall meet the requirements of AWWA Standard C900, latest revision for pressured rated pipe or SDR 21 CL 200. All PVC pipe shall be certified by NSF and listed in the NSF Standard 61 along with the NSF logo stamped on the pipe.

All PVC pipe shall have a minimum working pressure of 200 psi.

The method of joining pipe shall be as noted in the proposal or on the plan drawing and in accordance with the installation procedures following herein.

The elastomeric rings seal joints for plastic pressure pipe shall conform with the requirements of ASTM D3139. The joints shall have been tested and approved by the National Sanitation Foundation and certification of said approval shall be submitted.

2.3 Service connection between water main and meter shall be "K" copper tubing.

3. EXECUTION

3.1 General: Only competent workmen shall be employed on this phase of the work and equipment suitable for the execution of the work shall be utilized. Installation of ductile iron pipe shall conform to ANSI/AWWA Standard C600, and to the drawings.

3.2 Delivery of Materials to Job:

3.2.1 All materials shipped by rail shall be carefully inspected for damage in transit in the cars, and if such be found, same shall not be unloaded, except upon the instructions from the official freight agent. In the event of damaged pipe, same may be lifted out of the cars, and placed along the switch site, but must not be removed from the railroad company's property.

3.2.2 All materials delivered by truck shall be inspected as they are unloaded. Damaged pipe or materials shall not be left at the storage yard or taken to the job site, but shall be removed as soon as possible in order that rejected material will not be mistakenly used on construction.

3.2.3 All pipe fittings, valves, and other accessories shall be unloaded by the use of hoists or skidways. Same shall be handled in such manner as to avoid damage due to shock. Under no circumstances shall pipe be dropped to the ground from cars or trucks. Special precaution shall be taken to prevent the rolling of pipe to strike another forcefully.

3.3 Trench Excavation:

3.3.1 Machine-excavated trenches, as well as hand-excavated trenches, shall be cut to the alignment and configuration as shown on the drawings. Unless noted otherwise on the drawings, trenches shall be cut as deep as necessary on either side of natural depressions, ditches, waterways, etc. to provide minimum 48 inches of cover over the pipe. Excessive change in gradient will not be allowed. Line shall be constructed to a grade which prevents high spots which could pocket air and cause air binding of the line.

3.3.2 Trenches over four feet deep shall be braced and safety maintained until after laying operations have been completed. Trenches shall not be cut too far ahead of laying operations.

3.3.3 The maximum degree of deflection, either vertical or horizontal, shall not cause a pipe joint's annular clearance in the bell to be less than one-fourth inch (1/4") at its closest point. In case any portion of the trench is excavated below grade due to unsuitable soil conditions, further depth shall be refilled to the proper grade with crushed stone or other approved material.

3.3.4 Special care shall be taken to remove all rocks or boulders or ledge rock encountered so as to provide a clearance under the pipe of at least four inches, and this space shall be refilled with approved material and firmly compacted before laying the pipe.

3.4 Installation

3.4.1 The pipe shall be lowered in the trench piece by piece by means of derricks, ropes, or other suitable equipment. Under no circumstances shall pipe or other materials be dropped or dumped into the trench. Before lowering or while suspended over the trench, 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. A suitable swab shall be pushed through the pipe to insure that all foreign matter is removed from the pipe prior to laying.

3.4.2 To avoid improperly sized or spaced bell holes impairing the pipe length bearing on the trench bottom, bell holes shall be dug by hand and only far enough ahead that accuracy of their proper location can be assured. They shall be of minimum size, yet providing ample room that the joint may be properly and efficiently made. Machine-cut bell holes shall not be permitted.

3.4.3 Water mains must be laid at least 10 feet horizontally from any existing or proposed sewer. The distance must be measured edge to edge. In cases where it is not practical to maintain a ten foot separation, the department may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer and on either case, at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer. All installations shall fulfill the requirements of the Missouri Department of Natural Resources, Design Guide for Community Public Water Supplies, section 8.6, Separation of Water Mains, Sanitary Sewers, and Storm Sewers. A copy of Section 8.6 is included at the end of the section as reference.

3.4.4 Any connection to a backflow Hazard shall be provided with a backflow prevention assembly as specified in the Missouri Department of Natural resources, Public Drinking Water Program Design Guide, Section 8.8, backflow Prevention.

3.4.5 Each service meter shall be individually metered and construction in accordance with included Water Meter Installation Detail and Service Tap Detail.

3.4.6 Valves shall be provided at intervals not more that 500 feet in commercial districts and not more than one block or 800 feet in other districts or as shown on approved drawings.

3.4.7 All water supply piping which crosses surface water shall comply with the requirements of the Missouri Department of Natural Resources, Design for Community Water Supplies, Section 8.7 Surface Water Crossings. A copy of Section 8.7 is included at the end of this section.

3.5 Backfill and Compaction: Pipe shall be laid in a bed of select soil or 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. Pipe embedment material and trench backfill and compaction shall be as specified in Section 02221 - TRENCHING, BACKFILLING, AND COMPACTING, as detailed on the drawings.

3.6 Anchorage of Bends, Tees, and Plugs: On all pipe lines four inches (4") in diameter and larger, all tees, plugs, and caps, and bends exceeding 22-1/2 degrees shall be squarely anchored by suitable thrust concrete backing. Such concrete backing shall be so placed that the pipe or fitting joints will be accessible for repair. The concrete shall be 1:3:5 mix and shall be placed between solid ground and the fitting to be anchored. The area of the bearing on the pipe and the ground is each instance shall be a minimum of four square feet or as noted on the drawings.

3.6.1 Pipe joints immediately outside of buildings shall be properly and adequately restrained so as to prevent any movement due to internal pressures that would result in piping inside the building being subjected to an external force. Said restraint shall be provided by mechanical joint retained glands, restrainer glands, restrainer fittings, or other means approved by the Owner. Restraint shall be provided at the exterior pipe joints and not at joint or fittings located within the building.

3.7 Testing: Installed water lines shall be hydrostatically tested in accordance with latest edition of AWWA Standards and Manuals and as follows. Testing shall include both a "pressure test" of at least two hours duration for the purpose of blowing defective joints, and a "leakage test" to determine actual loss of water from the system. The use of compressed air for testing pipe will not be permitted. Contractor shall be responsible for properly restraining the end sections of water pipe to insure that the pipe does not move during testing (provide thrust blocks, etc.).

3.7.1 Pressure Test: After the pipe has been laid, all newly laid pipe shall be subjected to a hydrostatic pressure of at least 150 psi at the lowest point in the system.

3.7.1.1 Test pressure restrictions: Test pressures shall 1) be of at least 2-hour duration; 2) not vary by more than ± 5 psi; 3) not exceed twice the rated pressure of the valves of hydrants when the pressure boundary of the test section includes closed gate valves or hydrants.

3.7.1.2 Pressurization: Each valved or isolated section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Owner.

3.7.1.3 Air Removal: Before applying the specified test pressure, air shall be expelled completely from the pipe. After all the air has been expelled, the test pressure shall be applied.

3.7.1.4 Examination: All exposed pipe, fittings, valves, and joints shall be examined fully during the test. Any damaged or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test shall be repaired or replace with sound material and the test shall be repeated until it is satisfactory to the Owner.

3.7.2 Leakage Test: A leakage test shall be conducted concurrent with the pressure test and in accordance with the latest edition of AWWA Standards and Manuals.

3.7.2.1 Leakage Defined: Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

3.7.2.2 Allowable Leakage: No pipe installation will be accepted if the leakage is greater than that determined by the following:

$$\frac{L = (N)(D)(P^{1/2})}{7400}$$

in which L is the allowable leakage in gallons per hour; N is the number of joints in the length of pipeline tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test, in pounds per square inch gauge. When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed. When hydrants are in the test section, the test shall be made against the closed hydrant.

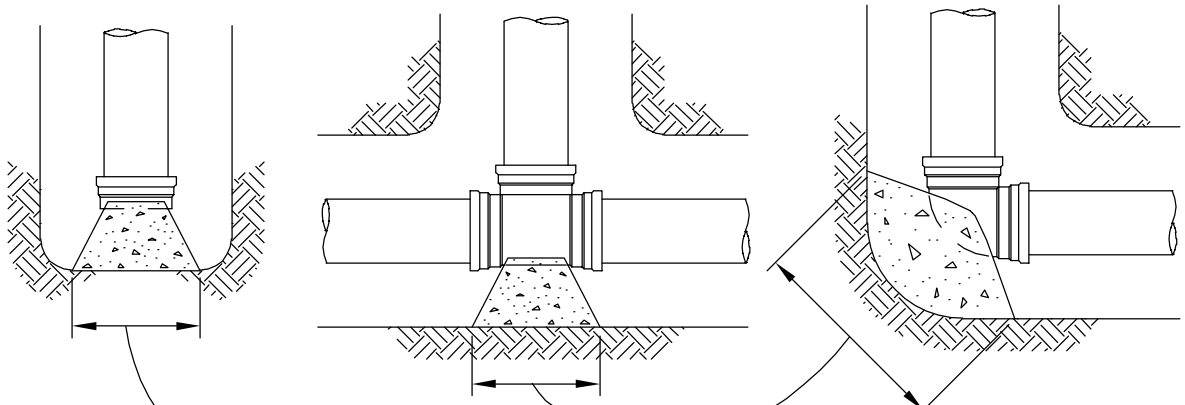
3.7.2.3 Acceptance of Installation: Acceptance shall be determined on the basis of allowable leakage. If any test of pipe laid disclosed leakage greater than that specified above, the Contractor shall, at his own expense, locate and repair the defective material until the leakage is within the specified allowance. All visible leaks are to be repaired regardless of the amount of leakage.

3.8 Flushing and Disinfecting Lines: All requirements of AWWA Standard C651 regarding disinfection shall apply. A copy of AWWA C651 is included at the end of this section for reference. Before placing the lines in service, all water mains shall be systematically and thoroughly flushed at a minimum velocity of 2.5 fps for the purpose of removing any remaining dirt or foreign matter, and then shall be disinfected by chlorination to a completely sterile condition to the satisfaction of the Owner and Missouri Department of Natural Resources. Chlorination shall produce a chlorine residual of not less than 25 ppm in the water at any and all points in the line after standing twenty-four hours in the pipe. After the 24-hour retention period, the heavily chlorinated water shall be flushed from the mains until the chlorine concentration in the water leaving the main falls to below 1mg/1. Chlorine residual determinations shall be made by the Contractor in the presence of the Owner's Representative to ascertain that the heavily chlorinated water has been removed from the piping.

3.8.1 Microbiological Quality: Within 48 hours after the flushing and disinfecting of all lines has been satisfactorily completed, the Contractor shall take two water samples from the line spaced 24 hours apart. The samples shall be taken by an independent laboratory satisfactory to the reviewing authority. The results shall be submitted to the reviewing authority for review. The test results of the two samples shall have satisfactory results in accordance with 10 CSR60-4.010 before placing the lines into the water system.

3.9 Repairs: In the event of leaks or breaks or other malfunctions of material within one year from the date of acceptance, the Contractor shall repair such defects at his expense or arrange with the Owner for expenses incurred in such repairs.

NOTE: ALL BURIED FITTINGS SHALL HAVE PLAIN CONCRETE THRUST BLOCKING, MINIMUM 3000 P.S.I. CONCRETE.

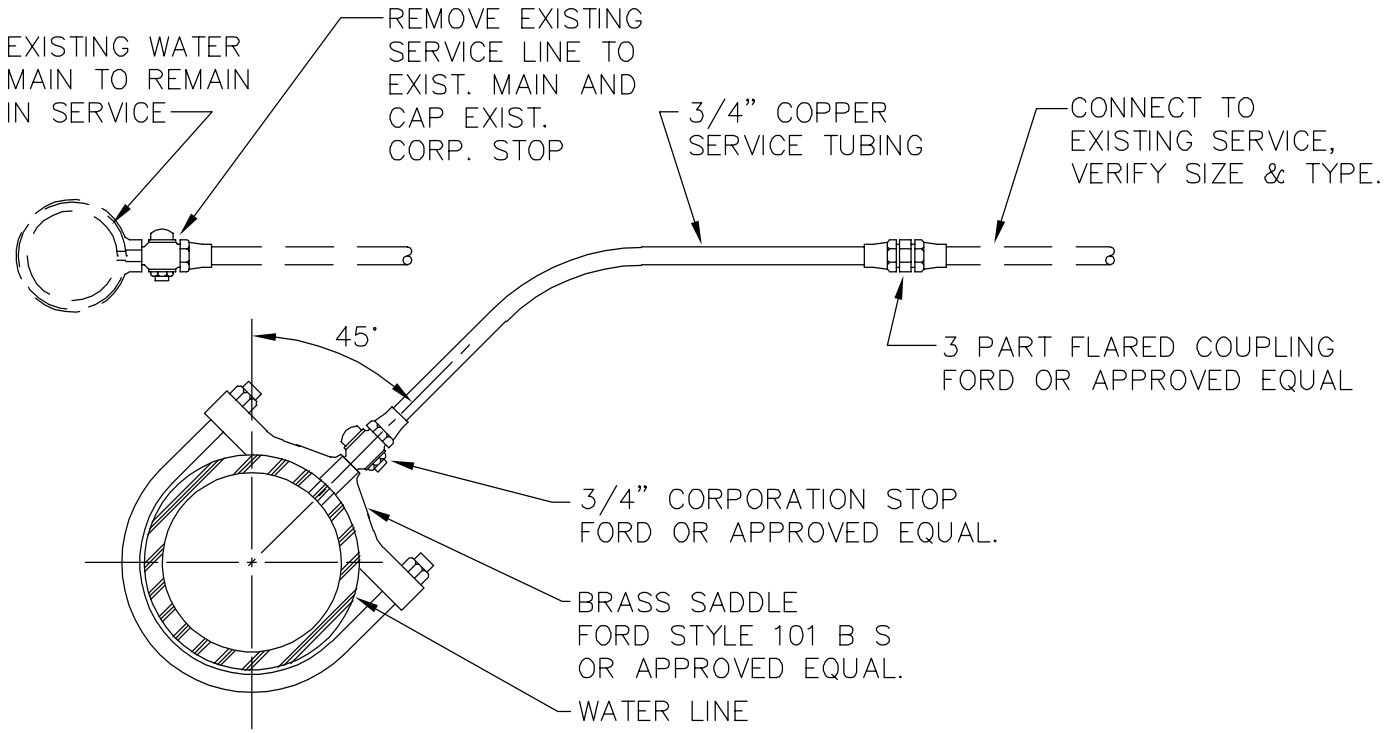


CONCRETE THRUST BLOCK SHALL HAVE A MINIMUM BEARING AREA OF 4 SQ. FT. ON UNDISTURBED SOIL.

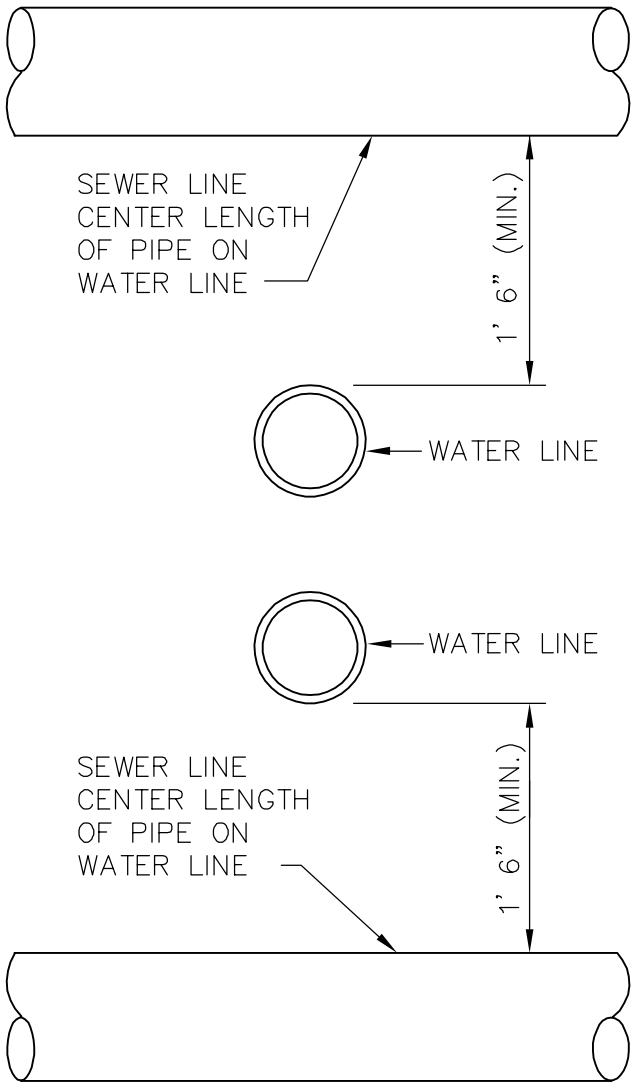
City of Monett, Missouri

Std. Spec.

TYPICAL THRUST BLOCKING



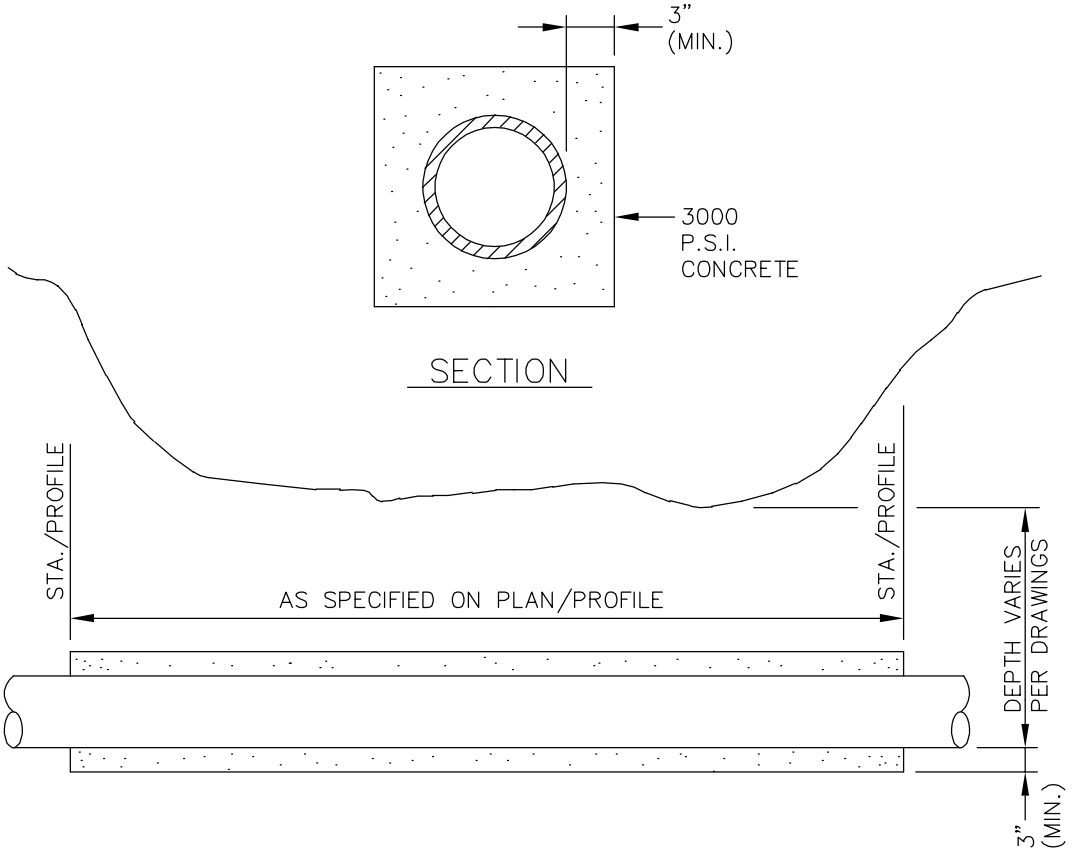
City of Monett, Missouri
Std. Spec. SERVICE TAP & CONNECTION



City of Monett, Missouri

Std. Spec.

WATER / SEWER CROSSING



City of Monett, Missouri

Std. Spec.

CONCRETE ENCASEMENT

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 Ration (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 with two component non-staining gray sealing

compound with polysulfide liquid polymers, gun grade with primer, installed in accordance with the manufacturer's recommendations.

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.

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. FORMS

11.1 Forms shall be true and rigid and built to the line, shape, and grade shown on the plans. They shall be made of sound and reasonable smooth lumber, plywood, or steel. Joints shall be mortar tight and forms shall be tied and braced to prevent any bulging or deflection during concreting. Cut cleanouts at bottom as required for removal of sawdust and debris. The Engineer's approval of the forms is required before placing concrete.

11.2 Before reusing forms, or when using second-hand lumber for forms, they shall be cleaned and all nails removed therefrom. Immediately before pouring, all forms shall be thoroughly cleaned of all dirt, debris, and foreign matter.

11.3 Forms for exposed concrete beams, girders, columns, pilasters and walls shall provide for a one (1) inch radius or flat bevel on external corners.

CONCRETE ADMIXTURES 03301

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.

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

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

l. Bedding normally consists of free flowing material such as gravel, sand, silty sand, or clayey sand. If this material is not used, a chipper should be used on the trencher to prepare the soil removed from the trench as embedment and backfill.
m. Embedment material diameter for plastic pipe shall be no greater than ½ inch for 4-inch diameter pipe, ¾ inch for 6 and 8-inch diameter pipes, and 1-inch for pipe diameters from 10 inches and greater.
n. Sand or other non-acidic granular material shall be used for pipe bedding, embedment and backfill in high traffic areas and under paved roads.
o. Backfill may consist of the excavated material, provided it is free from unsuitable matter such as large lumps of clay, frozen soil, organic material, boulders, or stones larger than 8 inches, or construction debris.
p. Width of trenches shall be at least four inches larger than the pipe's diameter. The minimum clear width of a trench should be the pipe outside diameter plus twelve inches to be wide enough to accommodate the compaction equipment.

8.5.3. Cover

All water mains shall be covered with at least 42 inches of earth or other insulation to prevent freezing. Lesser cover depth may be accepted in certain areas as approved by the department.

8.5.4. Thrust restraint

Properly installed reaction blocking or thrust restraint shall be provided for each dead end, valve, hydrant, flushing device, bend, T-connection, reducer, wye, cross, or other fitting. Reaction blocking or thrust restraint shall be designed to withstand the specific forces expected in the particular construction conditions. Wooden or steel posts or blocking made of wood or other biodegradable material shall not be used. Pre-cast concrete blocks should not be used. All restraining rods, bolts, and nuts should be stainless steel.

8.5.5. Pressure and leakage testing

All types of installed pipe shall be pressure tested and leakage tested in accordance with the latest edition of AWWA Standards and manuals.

8.5.6. Disinfection

All new, cleaned, or repaired water mains shall be disinfected in accordance with the latest edition of the AWWA Standard. The specifications shall include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains.

8.6. Separation of Water Mains, Sanitary Sewers and Combined Sewers.

When buried water mains are in close proximity to non-potable pipelines, the water mains are vulnerable to contamination that can pose a risk of waterborne disease outbreaks. For example, sewers (sanitary sewer mains and sewage force mains) frequently leak and saturate the surrounding soil with sewage due to structural failure, improperly constructed joints, and subsidence or upheaval of the soil encasing the sewer. If a nearby water main is depressurized and no or negative pressure occurs, that situation is a public health hazard. The public health

hazard is compounded if an existing sewer is broken during the installation or repair of the water main. Further, failure of a water main in close proximity to other pipelines may disturb their bedding and cause them to fail. To protect the public health, the following requirements shall be met. These requirements apply to horizontally directionally drilled pipe or pipe installed through other trenchless methods as well as pipe installed by conventional open-cut methods.

8.6.1. General

The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water and sewer pipes;
b. Soil conditions;
c. Service and branch connections into the water main and sewer line;
d. Compensating variations in the horizontal and vertical separations;
e. Space for repair and alterations of water and sewer pipes; and
f. Off-setting of water mains around manholes.

8.6.2. Parallel installation

The water main shall be located at least ten feet horizontally from any existing or proposed line carrying non-potable fluids such as, but not limited to drains, storm sewers, sanitary sewers, combined sewers, sewer service connections, and process waste or product lines. The distance shall be measured edge to edge.

In cases where it is not practical to maintain a ten-foot separation, the department may allow deviation on a case by case basis, if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a non-potable fluid line, provided that the water main is laid in a separate trench located as far away from the non-potable line as feasible and meets other specific construction requirements. Locating a water main on an undisturbed earth shelf located on one side of the non-potable line is not recommended and requires justification by the engineer and specific case-by-case approval of the department. In either case, an elevation shall be maintained such that the bottom of the water main is at least 18 inches above the top of the non-potable line while meeting minimum cover requirements.

In areas where the recommended separations cannot be obtained, either the waterline or the non-potable line shall be constructed of mechanical or manufactured restrained joint pipe, fusion welded pipe, or cased in a continuous casing. Casing pipe must be a material that is approved for use as water main. Conventional poured concrete is not an acceptable encasement.

8.6.3. Crossings

Water mains crossing sewers, or any other lines carrying non-potable fluids shall be laid to provide a minimum vertical clear distance of 18 inches between the outside of the water main and the outside of the non-potable pipeline. This shall be the case where the water main is either above or below the non-potable pipeline. An 18-inch separation is a structural protection measure to prevent the sewer or water main from settling and breaking the other pipe. At crossings, the full length of water pipe shall be located so both joints will be as far from the non-potable pipeline as possible but in

no case less than ten feet or centered on a 20-foot pipe. In areas where the recommended separations cannot be obtained either the waterline or the non-potable pipeline shall be constructed of mechanical or manufactured restrained joint pipe, fusion welded pipe, or cased in a continuous casing that extends no less than ten feet on both sides of the crossing. Special structural support for the water and sewer pipes may be required. Casing pipe must be a material that is approved for use as water main. Conventional poured concrete is not an acceptable encasement.

8.6.4. Exception

Any exception from the specified separation distances in paragraphs 8.6.2.and 8.6.3. must be submitted to the department for approval.

8.6.5. Force mains

There shall be at least a ten-foot horizontal separation between water mains and sanitary sewer force mains or other force mains carrying non-potable fluids and they shall be in separate trenches. In areas where the recommended separations cannot be obtained, either the waterline or the non-potable line shall be constructed of mechanical joint pipe or cased in a continuous casing, be constructed of mechanical joint pipe, or be jointless or fusion welded pipe. Where possible, the waterline shall also be at such an elevation that the bottom of the water main is at least 18 inches above the top of the non-potable line. Casing pipe must be a material that is approved for use as water main. Conventional poured concrete is not an acceptable encasement.

8.6.6. Sewer manholes

No waterline shall be located closer than ten feet to any part of a sanitary or combined sewer manhole. Where the separation cannot be obtained, the waterline shall be constructed of mechanical or manufactured restrained joint pipe, fusion welded pipe, or cased in a continuous casing. Casing pipe must be a material that is approved for use as water main. The full length of water pipe shall be located so both joints will be as far from the manhole as possible, but in no case less than ten feet or centered on a 20-foot pipe. No water pipe shall pass through or come into contact with any part of a sanitary or combined sewer manhole.

8.6.7. Disposal facilities

No water main shall be located closer than 25 feet to any wastewater disposal facility, agricultural waste disposal facility, or landfill. Water mains shall be separated by a minimum of 25 feet from septic tanks and wastewater disposal areas such as cesspools, subsurface disposal fields, pit privies, land application fields, and seepage beds.

8.7. Surface Water Crossings.

Surface water crossings present special problems, whether over or under water. The department should be consulted before final plans are prepared. Special detail drawings shall be submitted that are scaled and dimensioned to show the approximate bottom of the stream, the approximate

elevation of the low and high-water levels, and other topographic features. Mechanical, restrained, or fusion welded joint pipe shall be required in waterways and wet weather streams.

8.7.1. Above water crossings

The pipe shall be adequately supported and anchored, protected from damage and freezing and accessible for repair or replacement.

8.7.2. Underwater crossings

a. Flowing streams and water body crossings five hundred feet or less in length shall have a minimum cover of four feet over the pipe. When crossing water courses greater than 15 feet in width, the following shall be provided:
   1. The pipe shall be of special construction, having flexible watertight joints. Steel or ductile iron ball-joint river pipe shall be used for open cut crossings. Mechanical or restrained joint or fusion welded pipe may be used for open cut crossings, provided it is encased in a welded steel casing. Mechanical or restrained joint or fusion weld pipe shall be used for bored crossings.
   2. Adequate support and anchorage shall be provided on both sides of the stream.
   3. Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible and should not be subject to flooding.
   4. The valve closest to the supply source shall be in an accessible location and installed in a vault, manhole, or meter pit sized to allow the installation of leak detection equipment.
   5. Permanent taps shall be provided on each side of the valve within the manhole, vault, or meter pit to allow insertion of a small meter to determine leakage and for sampling purposes.
   6. Bank erosion is a major cause of stream crossing failures, and erosion protection measures such as rip rap have limited success. Stream movement and the history of bank erosion must be considered when choosing the length that the crossing pipe or casing shall extend beyond the upper edge of the stream channel. The stream crossing pipe or casing shall extend at least 15 feet beyond the upper edge of the stream channel on each side of the stream.
   7. Large river crossings such as those crossing the Missouri or Mississippi River require specialized design and shall be considered on a case-by-case basis.

b. For lake, water body, and flood plain crossings greater than 500 feet in length, the design shall consider the ability to access and repair or replace the pipe in these crossings. Consideration shall also be given to the ability to continue service to areas served by the crossing in the event of a submerged leak or pipe break.
   1. Submerged portions of pipe crossing proposed lakes shall not be buried when the submerged pipe is greater than 500 feet in length except for the transition from water to land.
   2. Steel or ductile iron ball-joint river pipe or fusion welded pipe shall be used under water during normal flow conditions. Mechanical, restrained joint, or fusion welded pipe shall be used in flood plains.
   3. Underwater installations shall be tested for leaks prior to installation.

ANSI/AWWA C651-05
(Revision of ANSI/AWWA C651-99)

American Water Works Association

The Authoritative Resource on Safe Water™

AWWA Standard

Disinfecting Water Mains

ANSI American National Standards Institute

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AWWA Standard

This document is an American Water Works Association (AWWA) standard. It is not a specification. AWWA standards describe minimum requirements and do not contain all of the engineering and administrative information normally contained in specifications. The AWWA standards usually contain options that must be evaluated by the user of the standard. Until each optional feature is specified by the user, the product or service is not fully defined. AWWA publication of a standard does not constitute endorsement of any product or product type, nor does AWWA test, certify, or approve any product. The use of AWWA standards is entirely voluntary. AWWA standards are intended to represent a consensus of the water supply industry that the product described will provide satisfactory service. When AWWA revises or withdraws this standard, an official notice of action will be placed on the first page of the classified advertising section of Journal AWWA

American National Standard

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Science and Technology

Committee Personnel

The AWWA Standards Committee on Disinfection of Facilities, which reviewed and approved this standard, had the following personnel at the time of approval:

Marc S. Solomon, *Chair*

General Interest Members

K.C. Choquette, Des Moines, Iowa	(AWWA)
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* Liaison, nonvoting

Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

Foreword

This Foreword is for information only and is not a part of ANSI/AWWA C651.

I. Introduction.

I.A. *Background.* This standard describes methods of disinfecting newly constructed potable-water mains; mains that have been removed from service for planned repairs or for maintenance that exposes them to contamination; mains that have undergone emergency repairs because of physical failure; and mains that, under normal operation, continue to show the presence of coliform organisms. The disinfecting agents discussed in this standard are chlorine solutions that may be derived from liquid chlorine (Cl_2), calcium hypochlorite ($Ca(OCl)_2$), or sodium hypochlorite (NaOCl). Combinations of free chlorine residual and contact time are provided.

I.B. *History.* This standard was first approved on Sept. 30, 1947, by the AWWA Board of Directors and published as 7D.2-1948, A Procedure for Disinfecting Water Mains. Revisions were approved by the AWWA Board of Directors on Sept. 14, 1948; Mar. 6, 1953; May 27, 1954; June 2, 1968; June 7, 1981; and June 20, 1999. All were done under the designation ANSI/AWWA C601, Standard for Disinfecting Water Mains. In 1986, the designation of the standard was changed to ANSI/AWWA C651, and the subsequent editions were approved by the AWWA Board of Directors on June 18, 1992, and June 20, 1999. This edition was approved on Jan. 16, 2005.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for all direct and indirect drinking water additives. Other members of the original consortium included the American Water Works Association Research Foundation (AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or contact with, drinking water rests with individual states.* Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health

*Persons outside of the US should contact the appropriate authority having jurisdiction.

effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on April 7, 1990.
2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF, NSF*/ANSI† 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.
4. Other references, including AWWA standards, *Food Chemicals Codex, Water Chemicals Codex*,‡ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 60. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 60 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C651 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements including applicable standards.
2. Determine the status of certifications by all parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

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* NSF International, 789 N. Dixboro Rd., Ann Arbor, MI 48105.

† American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

‡ Both publications available from National Academy of Sciences, 500 Fifth St., N.W.,Washington, DC 20001.

II. Special Issues.

II.A. *Information on Application of This Standard.* Generally, it is easier to disinfect a new main rather than one that has had emergency repairs. The unsanitary conditions created when an existing main bursts or is cut into are likely to be difficult to control. The need to quickly restore water service to the community requires more rapid disinfection procedures than those prescribed for newly constructed mains.

Crews responsible for the repair of mains should be aware of the potential health hazards and should be trained to carefully observe prescribed construction practices and disinfection procedures.

Disinfection requires skills not necessarily mastered by competent construction crews. Some utilities prefer to disinfect water mains using specially trained treatment crews. However, because the effectiveness of disinfection depends, in large measure, on maintaining clean pipes and avoiding major contamination during construction, there are some advantages to having the construction crew retain the responsibility for disinfection. Furthermore, certain functions, such as placing tablets, must be performed by the construction crew. In either case, it is strongly recommended that pipe crews be aware of the need to maintain clean pipes and avoid contamination.

While bacteriological testing in accordance with Sec. 5.1 is used to verify the absence of coliform organisms and is generally accepted as verification that disinfection of the pipeline has been accomplished, following sanitary practices for handling and installation of pipe, valves, fittings, and accessories, coupled with adequate flushing of the line before disinfection, is necessary to ensure that the disinfected pipeline will be ready for connection to the water system. Failure to pass the bacteriological test requires that the flushing or disinfection process be repeated. It must be remembered that the final water quality test is not the primary means for certifying the sanitary condition of a main. The sanitary handling of materials, the practices during construction, and the continual inspection of the work are the primary means for ensuring the sanitary condition of the water main.

Three methods of disinfecting newly constructed water mains are described in this standard: the tablet method, the continuous-feed method, and the slug method. The utility should decide which of these methods is most suitable for a given situation. Factors to consider when choosing a method should include the length and diameter of the main, type of joints present, availability of materials, equipment required for disinfection, training of the personnel who will perform the disinfection, and safety concerns. For example, the continuous-feed or slug methods should be

used with gas chlorination only when properly designed and constructed equipment is available; makeshift equipment is not acceptable when liquid-chlorine cylinders are used.

Thorough consideration should be given to the impact of highly chlorinated water flushed into the waste environment. If there is any question that damage may be caused by chlorinated-waste discharge (to fish life, plant life, physical installations, or other downstream water uses of any type), then an adequate amount of reducing agent should be applied to water being disposed of in order to thoroughly neutralize the chlorine residual remaining in the water.

The tablet method cannot be used unless the main can be kept clean and dry. It cannot be used in large-diameter mains if it is necessary for a worker to enter the main to grout joints or perform inspection, because the tablets may release toxic fumes after exposure to moist air. When using the tablet method, the chlorine concentration is not uniform throughout the main, because the hypochlorite solution is dense and tends to concentrate at the bottom of the pipe. The use of the tablet method precludes preliminary flushing. The tablet method is convenient to use in mains having diameters up to 24 in., and it requires no special equipment.

The continuous-feed method is suitable for general application. Preliminary flushing removes light particulates from the main but not from the pipe-joint spaces. The chlorine concentration is uniform throughout the main.

The slug method is suitable for use in large-diameter mains where the volume of water makes the continuous-feed method impractical and difficult to achieve for short attachments. The slug method results in appreciable savings of chemicals used to disinfect long, large-diameter mains. Also, this method reduces the volume of heavily chlorinated water to be flushed to waste.

The purpose of all three chlorination methods is to disinfect water lines, resulting in an absence of coliforms as confirmed by laboratory analysis. As noted above, the three methods attempt to provide flexibility in responding to specific situations. The tablet and continuous-feed methods both have initial chlorine concentrations of 25 mg/L and a minimum contact time of 24 hr. Because the tablet method cannot be flushed and cleaned prior to disinfection, the required free chlorine residual must be detectable after 24 hr. Because the continuous-feed method can be used to flush particles and *prechlorinate* with calcium hypochlorite granules, a higher free chlorine residual of 10 mg/L is required after 24 hr. To meet the needs of situations requiring reduced contact times, the slug feed method allows only a 3-hr contact time, but

requires a 100-mg/L initial chlorine dosage. While the contact time of each method may not be identical, the end result, absence of coliforms, is the same for all three methods.

III. Use of This Standard. It is the responsibility of the user of an AWWA Standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Purchaser Options and Alternatives.* This standard is written as though the disinfection work will be performed by the purchaser's personnel. Where the work is to be done for a separate contract or as part of a contract for installing mains,* appropriate provisions should be included in the purchase documents to ensure that the constructor is specifically instructed as to their responsibilities. The following items should be provided by the purchaser:

1. Standard used—that is, ANSI/AWWA C651, Standard for Disinfection of Water Mains.
2. Approval requirements before use.
3. Those procedures included in the standard, which are designated as optional, that are to be included in the purchase documents.
4. Form of chlorine to be used (Sec. 4.1.1, 4.1.2, and 4.1.3).
5. Method of chlorination (Sec. 4.4.2, 4.4.3, and 4.4.4).
6. Flushing locations, rates of flushing, and locations of drainage facilities (Sec. 4.4.3.2, 4.5.1, and 4.5.2).
7. Responsibility for tapping existing mains and connections to new mains (Sec. 4.4.3.3[1], 4.4.3.3[2], and 4.6).
8. The number and frequency of samples for bacteriological tests (Sec. 5.1.1, 5.1.2, 5.1.4, and 5.2).
9. Method of taking samples (Sec. 5.1.3).
10. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects is required, in addition to the Safe Drinking Water Act.
11. Details of other federal, state, local, and provisional requirements.

III.B. *Modification to Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided by the purchaser.

*Refer to other AWWA standards and manuals for design criteria and installation procedures for various pipe materials.

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. Under Sec. 5.1.4 sample results, Heterotrophic Plate Counts greater than 500 colony forming units require additional flushing.
2. Table 1 has been corrected.
3. Ascorbic Acid was added in Appendix C as a neutralizing agent.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer and Technical Support Group at (303) 794-7711, FAX (303) 795-7603, or write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail at standards@awwa.org.

ANSI/AWWA C651-05
(Revision of ANSI/AWWA C651-99)

American Water Works Association

AWWA Standard

Disinfecting Water Mains

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes essential procedures for the disinfection of new and repaired potable water mains. New water mains shall be disinfected before they are placed in service. Water mains taken out of service for inspection, repair, or other activities that might lead to contamination of water shall be disinfected before they are returned to service.

Sec. 1.2 Purpose

The purpose of this standard is to define the minimum requirements for the disinfection of water mains, including the preparation of water mains, application of chlorine, and sampling and testing for the presence of coliform bacteria.

Sec. 1.3 Application

This standard can be referenced in the purchase documents for the disinfection of water mains and can be used as a guide for the preparation of water mains, application of chlorine, and sampling and testing for the presence of coliform bacteria. The stipulations of this standard apply when this document has been referenced and only to the disinfection of water mains.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, they form a part of this standard to the extent required within the standard. In any case of conflict, the requirements of this standard shall prevail.

ANSI*/AWWA B300—Hypochlorites.

ANSI/AWWA B301—Liquid Chlorine.

AWWA Manual M12, *Simplified Procedures for Water Examination.* AWWA: Denver, Colo.

Standard Methods for the Examination of Water and Wastewater. APHA,† AWWA, and WEF.‡ Washington, D.C.

SECTION 3: DEFINITIONS

1. *Constructor:* The party that furnishes the work and materials for placement or installation.

2. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.

3. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

SECTION 4: REQUIREMENTS

Sec. 4.1 Forms of Chlorine for Disinfection

The forms of chlorine that may be used in the disinfection operations are liquid chlorine, sodium hypochlorite solution, and calcium hypochlorite granules or tablets.

4.1.1 *Liquid chlorine.* Liquid chlorine conforming to ANSI/AWWA B301 contains 100 percent available chlorine and is packaged in steel containers usually of 100-lb, 150-lb, or 1-ton (45.4-kg, 68.0-kg, or 907.2-kg) net chlorine weight. Liquid

*American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

†American Public Health Association, 800 I St., N.W., Washington, DC 20001.

‡Water Environment Federation, 601 Wythe St., Alexandria, VA 22314.

chlorine shall be used only (1) in combination with appropriate gas-flow chlorinators and ejectors to provide a controlled high-concentration solution feed to the water to be chlorinated; (2) under the direct supervision of someone familiar with the biological, chemical, and physical properties of liquid chlorine and who is trained and equipped to handle any emergency that may arise; and (3) when appropriate safety practices are observed to protect working personnel and the public.

4.1.2 *Sodium hypochlorite.* Sodium hypochlorite conforming to ANSI/AWWA B300 is available in liquid form in glass, rubber-lined, or plastic containers typically ranging in size from 1 qt (0.95 L) to 5 gal (18.92 L). Containers of 30 gal (113.6 L) or larger may be available in some areas. Sodium hypochlorite contains approximately 5 percent to 15 percent available chlorine, and the storage conditions and time must be controlled to minimize its deterioration. (Available chlorine is expressed as a percent of weight when the concentration is 5 percent or less, and usually as a percent of volume for higher concentrations. Percent × 10 = grams of available chlorine per liter of hypochlorite.)

4.1.3 *Calcium hypochlorite.* Calcium hypochlorite conforming to ANSI/AWWA B300 is available in granular form or in 5-g tablets, and must contain approximately 65 percent available chlorine by weight. The material should be stored in a cool, dry, and dark environment to minimize its deterioration.

CAUTION: Tablets dissolve in approximately 7 hr and must be given adequate contact time. Do not use calcium hypochlorite intended for swimming pool disinfection, as this material has been sequestered and is extremely difficult to eliminate from the pipe after the desired contact time has been achieved.

Sec. 4.2 Basic Disinfection Procedure

The basic disinfection procedure consists of

1. Inspecting materials to be used to ensure their integrity.
2. Preventing contaminating materials from entering the water main during storage, construction, or repair and noting potential contamination at the construction site.
3. Removing, by flushing or other means, those materials that may have entered the water main.
4. Chlorinating any residual contamination that may remain, and flushing the chlorinated water from the main.

5. Protecting the existing distribution system from backflow caused by hydrostatic pressure test and disinfection procedures.

6. Documenting that an adequate level of chlorine contacted each pipe to provide disinfection.

7. Determining the bacteriological quality by laboratory test after disinfection.

8. Final connection of the approved new water main to the active distribution system.

Sec. 4.3 Preventive and Corrective Measures During Construction

4.3.1 *General.* Heavy particulates generally contain bacteria and prevent even very high chlorine concentrations from contacting and killing these organisms. Therefore, the procedures of this section must be observed to assure that a water main and its appurtenances have been thoroughly cleaned for the final disinfection by chlorination. Also, any connection of a new water main to the active distribution system prior to the receipt of satisfactory bacteriological samples may constitute a cross-connection. Therefore, the new main must be isolated until bacteriological tests described in Sec. 5 of this standard are satisfactorily completed.

4.3.2 *Keeping pipe clean and dry.* The interiors of pipes, fittings, and valves shall be protected from contamination.

4.3.2.1 Openings. Openings in the pipeline shall be closed with watertight plugs when pipe laying is stopped at the close of the day's work or for other reasons, such as rest breaks or meal periods. Rodent-proof plugs may be used when watertight plugs are not practicable and when thorough cleaning will be performed by flushing or other means.

4.3.2.2 Stringing pipe. Pipe delivered for construction shall be strung to minimize the entrance of foreign material.

4.3.2.3 Delays. Delay in placement of delivered pipe invites contamination. The more closely the rate of delivery is correlated to the rate of pipe laying, the lower the risk of contamination.

4.3.3 *Joints.* Joints of pipe in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is free of standing water and mud that may enter the pipe.

4.3.4 *Packing materials.* Yarning or packing material shall consist of molded or tubular rubber rings, rope of treated paper, or other approved materials. Materials such as jute or hemp shall not be used. Packing material shall be handled in a manner

that avoids contamination. If asbestos rope is used, asbestos shall be prevented from entering into the water-carrying portion of the pipe.

4.3.5 *Sealing materials.* No contaminated material or any material capable of supporting growth of microorganisms shall be used for sealing joints. Sealing material or gaskets shall be handled in a manner that avoids contamination. The lubricant used in the installation of sealing gaskets shall be suitable for use in potable water and shall not contribute odors. It shall be delivered to the job in closed containers and shall be kept clean and applied with dedicated, clean applicator brushes.

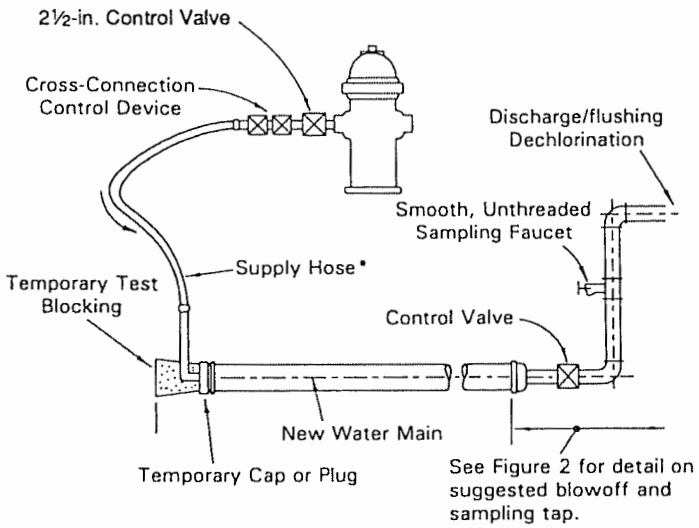
4.3.6 *Cleaning and swabbing.* If dirt enters the pipe, it shall be removed and the interior pipe surface swabbed with a 1 to 5 percent hypochlorite disinfecting solution. If, in the opinion of the purchaser, the dirt remaining in the pipe will not be removed using the flushing operation, then the interior of the pipe shall be cleaned using mechanical means, such as a hydraulically propelled foam pig (or other suitable device acceptable to the purchaser) in conjunction with the application of a 1 percent hypochlorite disinfecting solution. The cleaning method used shall not force mud or debris into the interior pipe-joint spaces and shall be acceptable to the purchaser.

4.3.7 *Wet-trench construction.* If it is not possible to keep the pipe and fittings dry during installation, the water that may enter the pipe-joint spaces shall contain an available chlorine concentration of approximately 25 mg/L. This may be accomplished by adding calcium hypochlorite granules or tablets to each length of pipe before it is lowered into a wet trench or by treating the trench water with hypochlorite tablets.

4.3.8 *Flooding by storm or accident during construction.* If the main is flooded during construction, it shall be cleared of the floodwater by draining and flushing with potable water until the main is clean. The section exposed to the floodwater shall then be filled with a chlorinated potable water that, at the end of a 24-hr holding period, will have a free chlorine residual of not less than 25 mg/L. The chlorinated water may then be drained or flushed from the main. After construction is completed, the main shall be disinfected using the continuous-feed or slug method.

4.3.9 *Backflow protection (optional).** As an optional procedure (if required by the purchaser), the new water main shall be kept isolated from the active distribution system using a physical separation (see Figure 1) until satisfactory bacteriological testing has been completed and the disinfectant water flushed out.

*Optional Sec. 4.3.9 is not included as part of the standard unless required by the purchaser.



*Clean potable-water hose only. Size and number of taps per Table 3. This hose must be removed during the hydrostatic pressure test.

NOTE: Figure 1 applies to pipes with diameters 4 in. (100 mm) through 12 in. (300 mm). Larger sizes must be handled on a case-by-case basis.

Figure 1 Suggested temporary flushing/testing connection

Water required to fill the new main for hydrostatic pressure testing, disinfection, and flushing shall be supplied through a temporary connection between the distribution system and the new main. The temporary connection shall include an appropriate cross-connection control device consistent with the degree of hazard (a double check valve assembly or a reduced pressure zone assembly) and shall be disconnected (physically separated) from the new main during the hydrostatic pressure test. It will be necessary to reestablish the temporary connection after completion of the hydrostatic pressure test to flush out the disinfectant water prior to final connection of the new main to the distribution system. NOTE: Exposure to high levels of chlorine or high pH can cause severe irritation to customers. Also, the chlorinated water can be high in disinfection by-products.

Sec. 4.4 Methods of Chlorination

4.4.1 *General.* Three methods of chlorination are explained in this section: tablet, continuous feed, and slug. Information in the Foreword is helpful in determining the appropriate method. The tablet method gives an average chlorine dose of approximately 25 mg/L; the continuous-feed method gives a 24-hr chlorine

residual of not less than 10 mg/L; and the slug method gives a 3-hr exposure of not less than 50-mg/L free chlorine.

4.4.1.1 Preflushing of source water. The source of potable water used for disinfection and pressure testing shall be flushed prior to its use to ensure that contaminants or debris are not introduced into the new pipe. Adequate drainage must be provided during flushing. Drainage should take place away from the construction area. During the contact period, it is recommended that the valve isolating the new main from this system (if applicable) be tagged to prevent unintentional release of the elevated chlorine residual water into the system.

4.4.2 *Tablet method.* The tablet method consists of placing calcium hypochlorite granules or tablets in the water main as it is being installed and then filling the main with potable water when installation is completed. This method may be used only if the pipes and appurtenances are kept clean and dry during construction.

4.4.2.1 Placing of calcium hypochlorite granules. During construction, calcium hypochlorite granules shall be placed at the upstream end of the first section of pipe, at the upstream end of each branch main, and at 500-ft intervals. The quantity of granules shall be as shown in Table 1.

WARNING: This procedure must not be used on solvent-welded plastic or on screwed-joint steel pipe because of the danger of fire or explosion from the reaction of the joint compounds with the calcium hypochlorite.

Table 1 Ounces of calcium hypochlorite granules to be placed at beginning of main and at each 500-ft interval

Pipe Diameter *(d)*		Calcium Hypochlorite Granules	
in.	*(mm)*	*oz*	*(g)*
4	100	1.7	48
6	150	3.8	108
8	200	6.7	190
10	250	10.5	298
12	300	15.1	428
14 and larger	(350 and larger)	$D^2 \times 15.1$	$D^2 \times 428$

Where D is the inside pipe diameter in feet $D = d/12$

Table 2 Number of 5-g calcium hypochlorite tablets required for dose of 25 mg/L*

Pipe Diameter		Length of Pipe Section, *ft (m)*				
		13 (4.0) or less	18 (5.5)	20 (6.1)	30 (9.1)	40 (12.2)
in.	*(mm)*	Number of 5-g Calcium Hypochlorite Tablets				
4	(100)	1	1	1	1	1
6	(150)	1	1	1	2	2
8	(200)	1	2	2	3	4
10	(250)	2	3	3	4	5
12	(300)	3	4	4	6	7
16	(400)	4	6	7	10	13

*Based on 3.25-g available chlorine per tablet; any portion of tablet rounded to the next higher integer.

4.4.2.2 Placing of calcium hypochlorite tablets. During construction, 5-g calcium hypochlorite tablets shall be placed in each section of pipe. Also, one tablet shall be placed in each hydrant, hydrant branch, and other appurtenance. The number of 5-g tablets required for each pipe section shall be $0.0012\ d^2L$ rounded to the next higher integer, where d is the inside pipe diameter, in inches, and L is the length of the pipe section, in feet. Table 2 shows the number of tablets required for commonly used sizes of pipe. The tablets shall be attached by a food-grade adhesive. There shall be adhesive only on the broadside of the tablet attached to the surface of the pipe. Attach tablets inside and at the top of the main, with approximately equal numbers of tablets at each end of a given pipe length. If the tablets are attached before the pipe section is placed in the trench, their position shall be marked on the section to indicate that the pipe has been installed with the tablets at the top.

4.4.2.3 Filling and contact. When installation has been completed, the main shall be filled with water at a rate to ensure that the water within the main will flow at a velocity no greater than 1 ft/sec (0.3 m/sec). Precautions shall be taken to ensure that air pockets are eliminated. This water shall remain in the pipe for at least 24 hr. If the water temperature is less than 41°F (5°C), the water shall remain in the pipe for at least 48 hr. As an optional procedure, if required by the purchaser, water used to fill the new main shall be supplied through a temporary connection that shall include an appropriate cross-connection control device, consistent with the degree of hazard, for backflow protection of the active distribution system (see Figure 1). A detectable free

chlorine residual should be found at each sampling point after the 24-hr period. The results must be reported.

4.4.3 *Continuous-feed method.* The continuous-feed method consists of placing calcium hypochlorite granules in the main during construction (optional), completely filling the main to remove air pockets, flushing the completed main to remove particulates, and filling the main with potable water. The potable water shall be chlorinated so that after a 24-hr holding period in the main there will be a free chlorine residual of not less than 10 mg/L.

4.4.3.1 Placing of calcium hypochlorite granules. At the option of the purchaser, calcium hypochlorite granules shall be placed in pipe sections as specified in Sec. 4.4.2.1. The purpose of this procedure is to provide a strong chlorine concentration in the first flow of flushing water that flows down the main. In particular, this procedure is recommended when the type of pipe is such that this first flow of water will flow into annular spaces at pipe joints.

4.4.3.2 Preliminary flushing. Before the main is chlorinated, it shall be filled to eliminate air pockets and flushed to remove particulates. The flushing velocity in the main shall not be less than 2.5 ft/sec (0.76 m/sec) unless the purchaser determines that conditions do not permit the required flow to be discharged to waste. Table 3

Table 3 Required flow and openings to flush pipelines (40 psi [276 kPa] residual pressure in water main)*

Pipe Diameter		Flow Required to Produce 2.5 ft/sec (approx.) Velocity in Main		Size of Tap, *in.* (*mm*)			Number of 2½-in. (64-mm) Hydrant Outlets
				1 (25)	1½ (38)	2 (51)	
in.	(*mm*)	*gpm*	(*L/sec*)	Number of Taps on Pipe†			
4	(100)	100	(6.3)	1	—	—	1
6	(150)	200	(12.6)	—	1	—	1
8	(200)	400	(25.2)	—	2	1	1
10	(250)	600	(37.9)	—	3	2	1
12	(300)	900	(56.8)	—	—	2	2
16	(400)	1,600	(100.9)	—	—	4	2

*With a 40-psi (276-kPa) pressure in the main with the hydrant flowing to atmosphere, a 2½-in. (64-mm) hydrant outlet will discharge approximately 1,000 gpm (63.1 L/sec); and a 4½-in. (114-mm) hydrant outlet will discharge approximately 2,500 gpm (160 L/sec).

†Number of taps on pipe based on discharge through 5 ft (1.5 m) of galvanized iron (GI) pipe with one 90° elbow.

shows the rates of flow required to produce a velocity of 2.5 ft/sec (0.76 m/sec) in commonly used sizes of pipe. Note that flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity and pigging of the main may be required.

For 24-in. (600-mm) or larger diameter mains, an acceptable alternative to flushing is to broom-sweep the main, carefully removing sweepings prior to chlorinating the main.

4.4.3.3 Procedure for chlorinating the main.

1. Water supplied from a temporary, backflow-protected connection to the existing distribution system or other approved supply source shall flow at a constant, measured rate into the newly installed water main. In the absence of a meter, the rate may be approximated using a Pitot gauge in the discharge, measuring the time to fill a container of known volume, or measuring the trajectory of the discharge and using the formula shown in Figure 2. The main should undergo hydrostatic testing prior to disinfection.

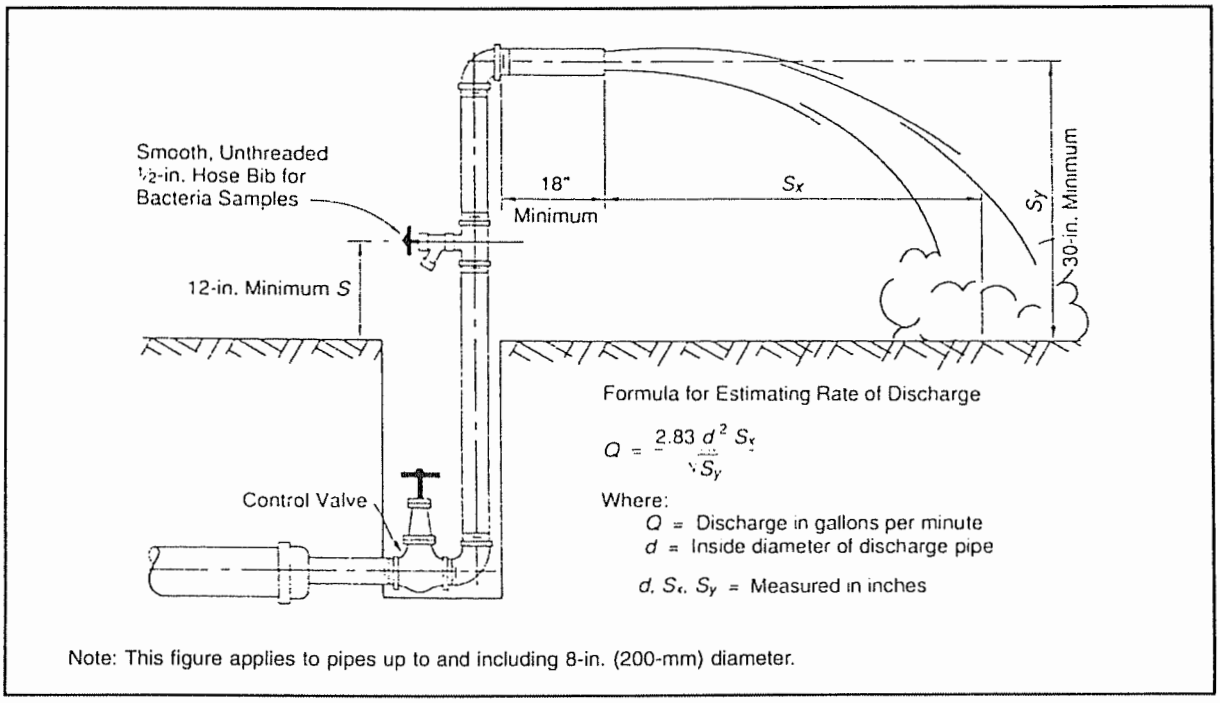


Figure 2 Suggested combination blowoff and sampling tap

2. At a point not more than 10 ft (3 m) downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 25 mg/L free chlorine. To ensure that this concentration is provided, measure the chlorine concentration at regular intervals in accordance with the procedures described in the current edition of *Standard Methods for the Examination of Water and Wastewater* or AWWA Manual M12, or using appropriate chlorine test kits (see Appendix A).

Table 4 gives the amount of chlorine required for each 100 ft (30.5 m) of pipe of various diameters. Solutions of 1 percent chlorine may be prepared with sodium hypochlorite or calcium hypochlorite. The latter solution requires 1 lb (454 g) of calcium hypochlorite in 8 gal (30.3 L) of water.

3. As an optional procedure, if required by the purchaser, water used to fill the new main during the application of chlorine shall be supplied through a temporary connection. This temporary connection shall be installed with an appropriate cross-connection control device, consistent with the degree of hazard for backflow protection of the active distribution system (see Figure 1). Chlorine application shall not cease until the entire main is filled with heavily chlorinated water. The chlorinated water shall be retained in the main for at least 24 hr, during which time valves and hydrants in the treated section shall be operated to ensure disinfection of the appurtenances. At the end of this 24-hr period, the treated water in all portions of the main shall have a residual of not less than 10 mg/L of free chlorine.

Table 4 Chlorine required to produce 25-mg/L concentration in 100 ft (30.5 m) of pipe by diameter

Pipe Diameter		100% Chlorine		1% Chlorine Solution	
in.	*(mm)*	*lb*	*(g)*	*gal*	*(L)*
4	(100)	0.013	(5.9)	0.16	(0.6)
6	(150)	0.030	(13.6)	0.36	(1.4)
8	(200)	0.054	(24.5)	0.65	(2.5)
10	(250)	0.085	(38.6)	1.02	(3.9)
12	(300)	0.120	(54.4)	1.44	(5.4)
16	(400)	0.217	(98.4)	2.60	(9.8)

4. Direct-feed chlorinators, which operate solely from gas pressure in the chlorine cylinder, shall not be used for the application of liquid chlorine. (The danger of using direct-feed chlorinators is that water pressure in the main can exceed gas pressure in the chlorine cylinder. This allows a backflow of water into the cylinder, resulting in severe cylinder corrosion and the escape of chlorine gas.) The preferred equipment for applying liquid chlorine is a solution-feed, vacuum-operated chlorinator and a booster pump. The vacuum-operated chlorinator mixes the chlorine gas in solution water; the booster pump injects the chlorine-gas solution into the main to be disinfected. Hypochlorite solutions may be applied to the water main with a gasoline or electrically powered chemical-feed pump designed for feeding chlorine solutions. Feed lines shall be made of material capable of withstanding the corrosion caused by the concentrated chlorine solutions and the maximum pressures that may be created by the pumps. All connections shall be checked for tightness before the solution is applied to the main.

4.4.4 *Slug method.* The slug method consists of placing calcium hypochlorite granules in the main during construction; completely filling the main to eliminate air pockets; flushing the main to remove particulates; and slowly flowing through the main a slug of water dosed with chlorine to a concentration of 100 mg/L. The slow rate of flow ensures that all parts of the main and its appurtenances will be exposed to the highly chlorinated water for a period of not less than 3 hr.

4.4.4.1 Placing calcium hypochlorite granules. Same as Sec. 4.4.3.1.

4.4.4.2 Preliminary flushing. Same as Sec. 4.4.3.2.

4.4.4.3 Chlorinating the main.

1. Same as Sec. 4.4.3.3(1).

2. At a point not more than 10 ft (3 m) downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 100 mg/L free chlorine. To ensure that this concentration is achieved, the chlorine concentration should be measured at regular intervals. The chlorine shall be applied continuously and for a sufficient period to develop a solid column, or slug, of chlorinated water that will, as it moves through the main, expose all interior surfaces to a concentration of approximately 100 mg/L for at least 3 hr.

3. The free chlorine residual shall be measured in the slug as it moves through the main. If at any time it drops below 50 mg/L, the flow shall be stopped; chlorination equipment shall be relocated at the head of the slug; and, as flow

resumes, chlorine shall be applied to restore the free chlorine in the slug to not less than 100 mg/L.

4. As the chlorinated water flows past fittings and valves, related valves and hydrants shall be operated so as to disinfect appurtenances and pipe branches.

Sec. 4.5 Final Flushing

4.5.1 *Clearing the main of heavily chlorinated water.* After the applicable retention period, heavily chlorinated water should not remain in prolonged contact with pipe. In order to prevent damage to the pipe lining or to prevent corrosion damage to the pipe itself, the heavily chlorinated water shall be flushed from the main fittings, valves, and branches until chlorine measurements show that the concentration in the water leaving the main is no higher than that generally prevailing in the distribution system or that is acceptable for domestic use.

4.5.2 *Disposing of heavily chlorinated water.* The environment to which the chlorinated water is to be discharged shall be inspected. If there is any possibility that the chlorinated discharge will cause damage to the environment, a neutralizing chemical shall be applied to the water to be wasted to thoroughly neutralize the residual chlorine (see Appendix C for neutralizing chemicals). Where necessary, federal, state, local, or provincial regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water.

Sec. 4.6 Final Connections to Existing Mains (Optional)*

As an optional procedure, if required by the purchaser, water mains and appurtenances must be completely installed, flushed, disinfected, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Sanitary construction practices must be followed during installation of the final connection so that there is no contamination of the new or existing water main with foreign material or groundwater.

4.6.1 *Connections equal to or less than one pipe length (≤18 ft [5.5 m]).* As an optional procedure (if required by the purchaser), the new pipe, fittings, and valve(s) required for the connection may be spray-disinfected or swabbed with a minimum 1–5 percent solution of chlorine just prior to being installed, if the total length of the

*Optional Sec. 4.6 is not included as part of the standard unless specifically identified by the purchase documents.

connection from the end of a new main to the existing main is equal to or less than 18 ft (5.5 m).

4.6.2 *Connections greater than one pipe length (>18 ft [5.5 m]).* As an optional procedure, if required by the purchaser, the pipe required for the connection must be set up aboveground, disinfected, and bacteriological samples taken, as described in Sec. 5, if the total length of the connection from the end of a new main to the existing main is greater than 18 ft (5.5 m). After satisfactory bacteriological sample results have been received for the predisinfected pipe, the pipe can be used in connecting the new main to the active distribution system. Between the time the satisfactory bacteriological sample results are received and the time that the connection piping is installed, the ends of the piping must be sealed with plastic wraps, watertight plugs, or caps.

Sec. 4.7 Disinfection Procedures When Cutting Into or Repairing Existing Mains

The following procedures apply primarily when existing mains are wholly or partially dewatered. After the appropriate procedures have been completed, the existing main may be returned to service prior to the completion of bacteriological testing in order to minimize the time customers are without water. Leaks or breaks that are repaired with clamping devices while the mains remain full of pressurized water may present little danger of contamination and therefore may not require disinfection.

4.7.1 *Trench treatment.* When an existing main is opened, either by accident or by design, the excavation will likely be wet and may be badly contaminated from nearby sewers. Liberal quantities of hypochlorite applied to open trench areas will lessen the danger from this pollution. Tablets have the advantage in this situation, because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation.

4.7.2 *Swabbing with hypochlorite solution.* The interior of pipe and fittings (particularly couplings and sleeves) used in making the repair shall be swabbed or sprayed with a 1 percent hypochlorite solution before they are installed.

4.7.3 *Flushing.* Thorough flushing is the most practical means of removing contamination introduced during repairs. If valve and hydrant locations permit, flushing toward the work location from both directions is recommended. Flushing shall be started as soon as the repairs are completed and shall be continued until discolored water is eliminated.

4.7.4 *Slug chlorination.* Where practical, in addition to the procedures previously described, the section of the main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated as described in Sec. 4.4.4. The dose may be increased to as much as 300 mg/L and the contact time reduced to as little as 15 min. After chlorination, flushing shall be resumed and continued until discolored water is eliminated and the chlorine concentration in the water exiting the main is no higher than the prevailing water in the distribution system or that which is acceptable for domestic use.

4.7.5 *Bacteriological samples.* Bacteriological samples following procedures in 5.1.3 shall be taken after repairs are completed to provide a record for determining the procedure's effectiveness. If the direction of flow is unknown, then samples shall be taken on each side of the main break. If positive bacteriological samples are recorded, then the situation shall be evaluated by the purchaser who can determine corrective action. Daily sampling shall be continued until two consecutive negative samples are recorded.

Sec. 4.8 Special Procedure for Caulked Tapping Sleeves

Before a tapping sleeve is installed, the exterior of the main to be tapped shall be thoroughly cleaned, and the interior surface of the sleeve shall be lightly dusted with calcium hypochlorite powder.

Tapping sleeves are used to avoid shutting down the main. After the tap is made, it is impossible to disinfect the annulus without shutting down the main and removing the sleeve. The space between the tapping sleeve and the tapped pipe is approximately 1/2 in. (13 mm), so that as little as 100 mg/ft^2 of calcium hypochlorite powder will provide a chlorine concentration of more than 50 mg/L.

SECTION 5: VERIFICATION

Sec. 5.1 Bacteriological Tests

5.1.1 *Standard conditions.* After final flushing and before the new water main is connected to the distribution system, two consecutive sets of acceptable samples, taken at least 24 hr apart, shall be collected from the new main. (NOTE: The pipe, the water loaded into the pipe, and any debris exert a chlorine demand that can interfere with disinfection.) At least one set of samples shall be

collected from every 1,200 ft (366 m) of the new water main, plus one set from the end of the line and at least one set from each branch. Samples shall be tested for bacteriological (chemical and physical) quality in accordance with *Standard Methods for the Examination of Water and Wastewater*; and shall show the absence of coliform organisms; and, if required, the presence of a chlorine residual. Turbidity, pH, and a standard heterotrophic plate count (HPC) test may be required at the option of the purchaser because new material does not typically contain coliforms but does typically contain HPC bacteria.

5.1.2 *Special conditions.* If trench water has entered the new main during construction or if, in the opinion of the purchaser, excessive quantities of dirt or debris have entered the new main, bacteriological samples shall be taken at intervals of approximately 200 ft (61 m), and the location shall be identified. Samples shall be taken of water that has stood in the new main for at least 16 hr after final flushing has been completed.

5.1.3 *Sampling procedure.* Samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate, as required by *Standard Methods for the Examination of Water and Wastewater.* No hose or fire hydrant shall be used in the collection of samples. (NOTE: For pipe repairs, if no other sampling port is available, well-flushed fire hydrants may be used with the understanding that they do not represent optimum sampling conditions.) A suggested combination blowoff and sampling tap used for mains up to and including 8-in. (200-mm) diameter is shown in Figure 2. There should be no water in the trench up to the connection for sampling. The sampling pipe must be dedicated and clean and disinfected and flushed prior to sampling. A corporation cock may be installed in the main with a copper-tube gooseneck assembly. After samples have been collected, the gooseneck assembly may be removed and retained for future use.

5.1.4 *Sample results.* If sample results from the lab indicate a measured HPC greater than 500 colony-forming units (cfu) per mL, flushing should be resumed and another coliform and HPC set of samples should be taken until no coliforms are present and the HPC is less than 500 cfu/mL.

5.1.5 *Record of compliance.* The record of compliance shall be the bacteriological test results certifying that the water sampled from the new water main is free of coliform bacteria contamination and is equal to or better than the bacteriologic water quality in the distribution system.

Sec. 5.2 Redisinfection

If the initial disinfection fails to produce satisfactory bacteriological results or if other water quality is affected, the new main may be reflushed and shall be resampled. If check samples also fail to produce acceptable results, the main shall be rechlorinated by the continuous-feed or slug method until satisfactory results are obtained—that being two consecutive sets of acceptable samples taken 24 hr apart.

NOTE: High velocities in the existing system, resulting from flushing the new main, may disturb sediment that has accumulated in the existing mains. When check samples are taken, it is advisable to sample water entering the new main to determine the source of turbidity.

SECTION 6: DELIVERY

This standard has no applicable information for this section.

APPENDIX A

Chlorine Residual Testing

This appendix is for information only and is not a part of ANSI/AWWA C651.

SECTION A.1: DPD DROP DILUTION METHOD (FOR FIELD TEST)

The N, N-diethyl-p-phenylenediamine (DPD) drop dilution method of approximating total residual chlorine is suitable for concentrations above 10 mg/L, such as those applied in the disinfection of water mains or tanks.

Sec. A.1.1 Apparatus

1. A graduated cylinder for measuring distilled water.
2. An automatic or safety pipette.
3. Two dropping pipettes that deliver a 1-mL sample in 20 drops. One pipette is for dispensing the water sample, and the other is for dispensing the DPD and buffer solutions. The pipettes should not be interchanged.
4. A comparator kit containing a suitable range of standards.

Sec. A.1.2 Reagents

1. DPD indicator solution. Prepare as prescribed in *Standard Methods for the Examination of Water and Wastewater.*

Sec. A.1.3 Procedure

1. Add 10 drops of DPD solution and 10 drops of buffer solution (or 20 drops of combined DPD–buffer solution) to a comparator cell.
2. Fill the comparator cell to the 10-mL mark with distilled water.
3. With a dropping pipette, add the water sample one drop at a time, mix until a red color is formed that matches one of the color standards.
4. Record the total number of drops used and the final chlorine reading obtained (that is, the chlorine reading of the matched standard).
5. Calculate the milligrams per liter of free residual chlorine as follows:

$$\text{mg/L chlorine} = \frac{\text{reading} \times 200}{\text{drops of sample}}$$

SECTION A.2: HIGH-RANGE CHLORINE TEST KITS

Several manufacturers produce high-range chlorine test kits that are inexpensive, easy to use, and satisfactory for the precision required.

APPENDIX B

Chlorine Dosages

This appendix is for information only and is not a part of ANSI/AWWA C651.

Table B.1 Amounts of chemicals required to produce various chlorine concentrations in 100,000 gal (378.5 m^3) of water*

Desired Chlorine Concentration in Water		Liquid Chlorine Required	Sodium Hypochlorite Required						Calcium Hypochlorite Required	
			5% Available Chlorine		10% Available Chlorine		15% Available Chlorine		65% Available Chlorine	
mg/L	*lb*	*(kg)*	*gal*	*(L)*	*gal*	*(L)*	*gal*	*(L)*	*lb*	*(kg)*
2	1.7	(0.77)	3.9	(14.7)	2.0	(7.6)	1.3	(4.9)	2.6	(1.18)
10	8.3	(3.76)	19.4	(73.4)	9.9	(37.5)	6.7	(25.4)	12.8	(5.81)
50	42.0	(19.05)	97.0	(367.2)	49.6	(187.8)	33.4	(126.4)	64.0	(29.03)

*Amounts of sodium hypochlorite are based on concentrations of available chlorine by volume. For either sodium hypochlorite or calcium hypochlorite, extended or improper storage of chemicals may have caused a loss of available chlorine.

Table B.2 Amounts of chemicals required to produce chlorine concentration of 200 mg/L in various volumes of water*

Volume of Water		Liquid Chlorine Required		Sodium Hypochlorite Required						Calcium Hypochlorite Required	
				5% Available Chlorine		10% Available Chlorine		15% Available Chlorine		65% Available Chlorine	
gal	*(L)*	*lb*	*(g)*	*gal*	*(L)*	*gal*	*(L)*	*gal*	*(L)*	*lb*	*(g)*
10	(37.9)	0.02	(9.1)	0.04	(0.15)	0.02	(0.08)	0.02	(0.08)	0.03	(13.6)
50	(189.3)	0.1	(45.4)	0.2	(0.76)	0.1	(0.38)	0.07	(0.26)	0.15	(68.0)
100	(378.5)	0.2	(90.7)	0.4	(1.51)	0.2	(0.76)	0.15	(0.57)	0.3	(136.1)
200	(757.1)	0.4	(181.4)	0.8	(3.03)	0.4	(1.51)	0.3	(1.14)	0.6	(272.2)

*Amounts of sodium hypochlorite are based on concentrations of available chlorine by volume. For either sodium hypochlorite or calcium hypochlorite, extended or improper storage of chemicals may have caused a loss of available chlorine.

APPENDIX C

Disposal of Heavily Chlorinated Water

This appendix is for information only and is not a part of ANSI/AWWA C651.

1. Check with the local sewer department for the conditions of disposal to the sanitary sewer.

2. Chlorine residual of water being disposed will be neutralized by treating with one of the chemicals listed in Table C.1.

Table C.1 Amounts of chemicals required to neutralize various residual chlorine concentrations in 100,000 gal (378.5 m^3) of water*

Residual Chlorine Concentration	Sulfur Dioxide (SO_2)		Sodium Bisulfite ($NaHSO_3$)		Sodium Sulfite (Na_2SO_3)		Sodium Thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)		Ascorbic Acid† ($C_6O_8H_6$)	
mg/L	*lb*	*(kg)*	*lb*	*(kg)*	*lb*	*(kg)*	*lb*	*kg*	*lb*	*kg*
1	0.8	(0.36)	1.2	(0.54)	1.4	(0.64)	1.2	(0.54)	2.1	(0.95)
2	1.7	(0.77)	2.5	(1.13)	2.9	(1.32)	2.4	(1.09)	4.2	(1.90)
10	8.3	(3.76)	12.5	(5.67)	14.6	(6.62)	12.0	(5.44)	20.9	(9.47)
50	41.7	(18.91)	62.6	(28.39)	73.0	(33.11)	60.0	(27.22)	104	(47.11)

*Except for residual chlorine concentration, amounts are in pounds (kilograms).

†User should confirm required dosage with chemical supplier.

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