CHAPTER 9
UTILITIES STANDARDS

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9.01 General

(A) Intent

The Utilities Standards are intended to complement the design standards specified in Chapter 4, "General Utilities Design," Chapter 5, "Water Design," Chapter 6, "Wastewater Design," Chapter 7, "Storm Water Design," and Chapter 11, "Technical Drawings," of these Standards, and provide minimum standards for the construction of public utilities improvements in public rights-of-way and public easements.

(B) Scope

These Standards apply to all city-operated public utility improvements within the City of Boulder service area. This chapter describes the construction of public utilities and other work within the public right-of-way including, but not limited to, work activities involved, materials used, installation methods, and required testing. The utilities construction requirements of this chapter are in addition to those set forth in Chapter 4, "General Utilities Design," Chapter 5, "Water Design," Chapter 6, "Wastewater Design," Chapter 7, "Storm Water Design," and Chapter 11, "Technical Drawings," of these Standards and the B.R.C. 1981.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, in order to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of streetscapes and the planting of trees, and may refer to one or more of the references listed in the References Section of these Standards.

(D) City Approval Required

All work associated with the construction of public utilities within or upon any City of Boulder public right-of-way or public easement is subject to City of Boulder approval or permit issuance as set forth in Chapter 8-5, "Work in the Public Right-Of-Way and Public Easements."

9.02 Excavation and Trenching

(A) General

(1) **Scope:** This section describes excavation and trenching, which includes the following:

(a) Necessary clearing, grubbing, and preparation of the site;

(b) Removal and disposal of debris; excavation and trenching as required;

(c) The handling, storage, transportation, and disposal of all excavated material;

(d) Necessary sheeting, shoring, and protection work;

(e) Preparation of subgrades;

(f) Pumping and dewatering as necessary or required;

(g) Protection of adjacent property

(h) Backfilling;

(i) Pipe embedment;

(j) Placement of fills;

(k) Surfacing and grading; and

(l) Other relevant work.

(2) **Quality Assurance:** All tests required for the preliminary review of materials shall be made by an acceptable independent testing laboratory; at the expense of the contractor. Two initial gradation tests shall be made for each type of pipe bedding, fill, or backfill material, and one additional gradation test shall be made for each additional 500 tons of each material. The contractor shall pay for all in-place field density tests, Proctor moisture-density tests, and relative density tests on the materials as required.

(B) Materials

(1) **General:** All bedding and backfill material shall be free of frozen material, organic material, and debris.

(2) **Pipe Bedding:** Bedding materials shall conform to the following requirements.

(a) Bedding Materials: Bedding materials shall not contain cinders or other material that may cause pipe corrosion.

(b) Concrete Arch Encasement: A concrete arch encasement is not required unless improper trenching or unexpected trench conditions require its use, as determined by the Director.

(c) Granular Bedding Material for Ductile Iron Pipe and PVC Pressure Pipe: This material shall be washed chips, 3/8 inch in nominal size. Table 9-1, " Granular Bedding Material for Ductile Iron Pipe and PVC Pressure Pipe," outlines the gradation requirements:

Table 9-1: Granular Bedding Material for Ductile Iron Pipe and PVC Pressure Pipe

Sieve Size or Designation	Percent Passing by Weight
1/2"	100%
3/8"	85-100%
No. 4	10-30%
No. 8	0-10%

NOTE: The Director may approve the use of squeegee sand conforming to the gradation in Table 9-3, "Granular Bedding for RCP Sewer Pipe," of these Standards.

(d) Compaction: All granular bedding material shall be compacted by vibrating or slicing with a shovel and placed in layers no more than 6 inches thick.

(e) Granular Bedding Material for PVC and HDPE Sewer Pipe: This material shall be imported, crushed, angular quarry rock. Table 9-2, "Granular Bedding Material for PVC and HDPE Sewer Pipe," outlines the gradation requirements (ASTM D448, No. 67):

Table 9-2: Granular Bedding Material for PVC and HDPE Sewer Pipe

Sieve Size or Designation	Total Passing (Percent by Weight)
3/4"	100%
3/8"	20-55%
No. 8	0-10%
No. 200	0-5%

(f) Granular Bedding Material for RCP Sewer Pipe: This material shall be squeegee sand. Table 9-3, "Granular Bedding Material for RCP Sewer Pipe," outlines the gradation requirements:

Table 9-3: Granular Bedding Material for RCP Sewer Pipe

Sieve Size or Designation	Total Passing (Percent by Weight)
3/8"	100%
No. 200	0-5%

(3) **Stabilization Material:** Stabilization material shall be placed on suitably prepared subgrades and compacted by vibration. Stabilization material shall be crushed rock or gravel; free from dust, clay, or trash; and graded 1 ½inch to No. 4 as defined in ASTM C33, and shall be compacted to not less than 70 percent relative density as determined by ASTM D4253 and D4254.

(4) **Trench Backfill:** Trench backfill is material placed above the pipe bedding and shall be flowable fill or an approved equivalent as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981.

(5) **Groundwater Barrier Material:** Groundwater barrier material shall be flowable fill or meet AASHTO soil classification SC or CL, free from stones, organic material or debris.

(6) **Flowable Fill: Flowable** fill, meeting the standards outlined in Table 9-4, "Flowable Fill Requirements," shall be used for trench backfill or for groundwater barriers.

Table 9-4: Flowable Fill Requirements

Ingredients	Lbs./C.Y.	Kg/m^3
Cement	50	30
Coarse Aggregate (AASHTO No. 57 or 67)	1,700	1,009
Fine Aggregate (AASHTO M 6)	1,845	1,095
Water (39 gallons) (147L)	325 (or as needed)	193 (or as needed)

(a) Enough water shall be used so that the flowable fill flows into place properly without excessive segregation. Approximately 39 gallons of water per cubic yard (193 liters per cubic meter) of flowable fill is normally needed. Additional water shall not be added to the mixture at the project site.

(b) The contractor may use aggregate that does not meet the specifications in Table 9-4, "Flowable Fill Requirements," if the cement is increased to 100 pounds per cubic

yard (60 kilograms per cubic meter) and the aggregate conforms to following gradation:

Sieve Size or Designation	Percent Passing
1" (25.0 mm)	100%
No. 200	0-10%

(c) The contractor may make the following substitutions in the flowable fill mix:

(i) Thirty pounds per cubic yard (18 kilograms per cubic meter) of cement and 30 pounds per cubic yard (18 kilograms per cubic meter) of fly ash for 50 pounds per cubic yard (30 kilograms per cubic meter) of cement, or

(ii) Sixty pounds per cubic yard (36 kilograms per cubic meter) of cement and 60 pounds per cubic yard (36 kilograms per cubic meter) of fly ash for 100 pounds per cubic yard (60 kilograms per cubic meter) of cement.

(d) The City reserves the right to review the use of recycled broken glass (glass cullet) as part or all of the aggregate.

(e) Compaction of flowable fill shall not be required

(f) The maximum layer thickness for flowable fill shall be 3-feet. Additional layers shall not be placed until the flowable fill has lost sufficient moisture to be walked on without indenting more than 2-inches. Any damage resulting form placing flowable fill in layers that are too thick or from not allowing sufficient time between placement of layers shall be repaired at the Contractor's expense.

(7) **Rock Backfill Material:** Rock backfill material shall be an imported graded material that meets either the 57/67 size requirements of ASTM C33 or the requirements for stabilization material specified in Subsection 9.02(B)(3).

(C) Execution

(1) **Site Preparation**

(a) All sites to be occupied by permanent construction shall be cleared of all logs, trees, roots, brush, tree trimmings, and other objectionable materials and debris. All stumps shall be grubbed. All waste materials shall be removed from the site and properly disposed.

(b) In natural areas where excavation will occur all topsoil shall be stripped or, in the absence of topsoil, the top 6 inches of surface material shall be stripped and stored separately from other excavated materials.

(c) For concrete walks, roadways, parking areas, and road crossings existing pavement shall be cut full depth to a true line before excavation. For Portland Cement pavements, cuts shall be made at existing joints.

(2) **Classification of Excavated Materials:** Excavated materials shall not be classified. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

(3) **Unauthorized Excavation:** Undermining or tunneling under walls, footings, slabs on grade, foundations, sidewalks, concrete or bituminous asphalt pavements, or any other surface or

subsurface facilities or structures shall not be permitted unless authorized by the Director. If unauthorized tunneling or undermining occurs, the contractor shall pay for all repairs and restorations the Director deems necessary. The repairs and restorations may include removing and replacing part or all of the affected facility or structure.

(4) **Stabilization of Subgrades**

(a) Subgrades for concrete structures and trench bottoms shall be firm, dense, thoroughly compacted and consolidated, and free from mud and muck.

(b) Subgrades for concrete structures or trench bottoms that are otherwise solid, but become mucky on top due to construction operations, shall be reinforced with crushed rock or gravel meeting the requirements for stabilization material, described in Subsection 9.02(B)(3) of these Standards and approved by the Director.

(c) Stabilization material shall be spread and compacted to a depth of not more than 4 inches. However, if the required depth exceeds 4 inches, the subgrade for concrete structures or trench bottom shall be re-excavated and all mud and muck removed and replaced with stabilization material, as required by Section 9.02(B)(3) of these Standards and approved by the Director.

(d) This material shall be placed, and compacted, as prescribed in these Standards. The finished elevation of stabilized subgrades shall not be above subgrade elevations indicated on the drawings.

(5) **Blasting:** Blasting or other use of explosives for excavation will not be permitted.

(6) **Shoring**

(a) All excavations shall be properly shored and braced to meet federal, state and local laws governing safe working conditions. The shoring shall be arranged so that no stress is placed on any portion of the completed work until the general construction thereof has proceeded far enough to provide ample strength.

(b) Shoring shall be removed as the work progresses. Trench sheeting shall not be pulled before backfilling unless the pipe strength is sufficient to carry trench loads based on trench width to the back of sheeting, nor shall sheeting be pulled after backfilling.

(c) Where trench sheeting is left in place, such sheeting shall not be braced against the pipe, but shall be supported in a manner that will preclude concentrated loads or horizontal thrusts on the pipe. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment has been completed.

(d) The contractor shall pay to repair any damage to pipes or structures resulting from missing, failed or improper shoring, sheeting, or bracing or any negligence on the part of the contractor.

(7) **Water Control and Dewatering**

(a) Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and until the structure to be built or the pipe to be installed is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

(b) All excavations for concrete structures or trenches that extend down to or below the groundwater table shall be dewatered by lowering and keeping the groundwater level

12 inches or more below the bottom of the excavation.

(c) Surface water shall be diverted or otherwise prevented from entering the excavated areas or trenches to the greatest extent practicable without causing damage to adjacent property.

(d) The contractor shall be responsible for the condition of any pipe or conduit used for drainage purposes. All such pipe or conduit shall be left clean and free of sediment.

(8) **Trench Excavation:** Trenches shall be excavated so that pipes can be laid according to the profiles, grades, elevations, and minimum cover shown on the drawings or specified in these Standards. Trench subgrades shall be clean and free of loose material of any kind.

(a) Excavation in Streets and Other Paved Surfaces: Excavations in streets with asphalt paving must be confined to the minimum width required to maintain a safe trench condition. The contractor shall pay for replacing any pavement damage resulting from their construction work. The Director will determine the limits of the damaged pavement needing replacement.

(b) Minimum Cover: Where pipe grades or elevations are not definitely fixed by the approved plans, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe as follows:

(i) Water lines require at least 4.5 feet of cover;

(ii) Sanitary sewers require at least 3 feet of cover; and

(iii) Storm sewers require at least 1.5 feet of cover.

(c) Trench Widths

(i) Trench widths shall be as shown below where the maximum trench width is measured at the top of the pipe barrel.

Pipe Diameter Inches	Maximum Trench Inches	Pipe Diameter Inches	Maximum Trench Inches
4	24	24	48
6	26	27	52
8	28	30	56
10	30	33	60
12	34	36	68
14	36	39	72
15	37	42	76
16	38	48	82
18	40	54	90
20	42	72	110
21	44		

(ii) If the stated maximum trench widths are exceeded, and if the Director determines that the combined dead- and live-loads will exceed the design

loadings on the pipe, the Director may require the contractor to either cradle the pipe in concrete or use a pipe of a stronger class. Remedial measures shall be entirely at the contractor's expense.

(iii) As illustrated on Drawing No. 4.03 in Chapter 11, "Technical Drawings," of these Standards, the pipe trench shall be excavated to a depth below the bottom of the pipe, backfilled with the specified granular bedding material, and compacted to the requirements of these Standards.

(d) Trench Walls

(i) The contractor may slope or bench trench sidewalls in areas where an increased trench width will not interfere with surface features or other utilities. Such sloping or benching shall terminate at least 1 foot above the top of the pipe barrel; from that point down, the trench wall shall be vertical.

(ii) The trenching operation, including the spoil bank and the sloping of trench sidewalls, shall be confined to the width of any permanent and temporary rights-of-way or easements.

(iii) A sufficient clear area shall be maintained away from the top edge of the excavation to avoid overloading that may cause slides or caving of the trench walls. The excavated material shall be kept trimmed to avoid inconveniencing the public and adjoining property owners. Unless otherwise authorized by the Director, all public thoroughfares and crossroads shall be kept open to traffic. When required by the Director, the contractor shall, at their own expense, provide open-cut bridging at street crossings, sidewalks, and other necessary points to prevent serious travel interruptions and to provide access to fire hydrants and public and private premises.

(e) Trench Preparation

(i) The trench shall be excavated only so far in advance of pipe laying as permitted by the Director. Trench preparation shall also conform to the details shown on the drawings in Chapter 11, "Technical Drawings," of these Standards.

(ii) Bell holes in the trench bottom shall be provided at each joint to permit the jointing to be made properly and to prevent the pipe from bearing on the pipe bells.

(iii) After excavation, the trench bottom shall be uniformly graded and hand-shaped so that the pipe barrel (exclusive of the joint) will have uniform and continuous bearing on thoroughly compacted pipe bedding material throughout the length of the pipe.

(iv) The trench grade shall permit the pipe spigot to be accurately centered in the preceding laid pipe joint, without lifting the pipe above the grade and without exceeding the permissible joint deflection. If raising the pipe subgrade is necessary, and approved by the Director, compacted bedding material may be used at the contractor's expense.

(f) Excavation Material: Excess excavated material shall be removed from the construction site and disposed of by the contractor.

(g) Rock Excavation: In the event of rock excavation, the bottom of the trench shall be lowered so that the bottom of the trench is 6 inches below the outside surface of the pipe. The space between the rock and the pipe shall be filled with granular bedding material. During its placement, the bedding material shall be shaped to provide support along the full length of pipe.

(9) **Installation of Pipe Bedding**

(a) Pipe bedding material shall consist of the material as specified in Subsection 9.02(B)(2) of this chapter. Bedding material shall be placed to provide the grade and elevation specified on the approved plans.

(b) After bedding material has been placed and approved, and after the pipe has been installed and approved, the additional granular bedding material shall be installed to an elevation 12 inches above the top of the pipe.

(10) **Installation of Trench Backfill**

(a) Backfilling during freezing weather shall not be performed, except by permission of the Director. No backfill shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill.

(b) Unless accurate results cannot be obtained, the compaction requirements shall conform to maximum dry density according to ASTM D698, Moisture- Density Relations of Soils (Standard Proctor). When the ASTM D698 test is not applicable, the percentage compaction requirements shall conform to ASTM D2049 Test for Relative Density of Cohesionless Soils.

(c) When required by the Director, the contractor shall excavate backfilled trenches for purposes of performing compaction tests at locations and depths determined by the Director. The contractor shall be responsible for reinstalling and recompacting the test excavations.

(d) All backfill above the bedding material shall be carefully placed and compacted. Except for the backfill requirements as set forth under Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981, approved backfill material shall be placed in loose lifts, not exceeding 8 inches thick, and shall be compacted by equipment and means approved by the Director. If the contractor wishes to use equipment and means other than what was approved for the project by the Director, the contractor shall submit, in writing, a request for approval of the proposed equipment and means to the Director for review and approval. Any approval by the Director, of an alternate method of compaction shall not relieve the contractor from providing a finished product that meets or exceeds all the intents and requirements of the approved plans and these Standards.

(e) All backfill shall be compacted to 95 percent of maximum laboratory dry density or 70 percent relative density. The material shall be within 2 percent of optimum moisture content.

(f) A loose layer of backfill material not more than 8 inches deep may be placed over concrete arch encasement or concrete reaction blocking after the concrete has reached its initial set, to aid curing. No additional backfill shall be placed over arch encasement or blocking until the concrete has been in place for at least 3 days.

(11) **Structural Excavation and Backfill**

(a) All structural excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

(b) Backfilling during freezing weather shall not be performed, except by permission of the Director. No backfill shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill.

(c) The quality and moisture content of materials for backfill around and outside of structures shall conform to the requirements for materials used for earthfills and embankments. Backfill materials shall be placed in loose lifts, not to exceed 8 inches in thickness, and shall be compacted to at least 95 percent of maximum dry density at optimum moisture content as determined by ASTM D698. Compaction of structure backfill by rolling will be permitted, provided the desired compaction is obtained and damage to the structure is prevented. Compaction of structure backfill by inundation with water will not be permitted.

(d) No backfill shall be deposited or compacted in water.

(e) Particular care shall be taken to compact structure backfill that will be beneath pipes, drives, roads, parking areas, walks, curbs, gutters, or other surface construction or structures. In addition, wherever a trench is to pass through structure backfill, the structure backfill shall be placed and compacted to an elevation not less that 12 inches above the top of pipe elevation before the trench is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

(12) **Restoration**

(a) Streets and Roadways: Any pavements disturbed during construction shall be repaired in accordance with the requirements as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981. All dirt and debris, including dust shall be removed from streets and paved surfaces within 3 days of the restoration of streets and paved surfaces. Initial removal of dirt and debris shall be made using a vacuum sweeper, after which the paved surfaces shall be cleaned using water hoses.

(b) Fencing and Culverts: Restore all existing structures to conditions equal to or exceeding existing structures.

(c) Landscape

(i) After other outside work has been finished, and backfilling and embankments completed and settled, all areas that are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas that have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth.

(ii) Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to hand work. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

(iii) Final grading and surfacing shall be smooth, even, and free from clods and stones larger than 1 inch in greatest dimension, weeds, brush, and other debris.

(iv) The top portion of backfill beneath established lawn areas shall be finished with at least 12 inches of topsoil corresponding to, or better than, that underlying adjoining lawn areas.

(v) The Director will clarify restoration of other minor items as construction proceeds. Such items must be restored to equal or exceed existing conditions.

(13) **Cleanup:** Prior to final inspection and acceptance, the contractor shall remove all rubbish and excess materials and leave the area in a neat, satisfactory condition.

(14) **Maintenance of Backfill: All** backfill shall be maintained in a satisfactory condition and all places showing signs of settlement shall be filled and maintained for a period of 2 years following the date of final acceptance of all work. When the contractor discovers or is notified by the City that any backfill is not in compliance with City standards, the contractor shall correct such conditions. Any utilities and road surfacing damaged by such settlement shall be repaired by the contractor to the satisfaction of the City. In addition, the contractor shall be responsible for the cost of all claims for damages due to settlement of backfilled areas.

9.03 Ductile Iron Pipe (DIP)

(A) General

(1) **Scope:** This section describes the furnishing and installation of ductile iron pipe and appurtenances for potable water mains, water services and fire lines in the pipe diameter size range of 4 inches to 24 inches.

(2) **Quality Assurance: Manufacturer's** certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Ductile Iron Pipe:**

(a) Unless revised on the approved drawings the ductile-iron pipe shall conform to ANSI A21.51, AWWA C151, Class 52 thickness. The interior of each length of pipe shall have a cement-mortar lining, conforming to the requirements set forth in ANSI A21.4, AWWA C104, of standard thickness. The exterior of the pipe shall be coated with standard bituminous coating approximately 1 mil thick.

(b) Unless otherwise specified the pipe joint shall be the "push-on" type, made in accordance with ANSI A21.11, AWWA C111, and the gaskets shall be standard for buried water service and as provided by the pipe manufacturer.

(c) The fittings shall be ductile-iron or cast-iron conforming to the requirements set forth in ANSI A21.10, AWWA C110. All cast-iron fittings 12 inches and smaller shall be Class 250, and fittings larger than 12 inches shall be Class 150. The interior of the fittings shall be epoxy or cement-mortar lined, as is required for the pipe with

a 1 mil bituminous exterior coating. The fittings shall have mechanical joints in accordance with ANSI A21.11, AWWA C111. The gaskets for the joints shall be suitable for potable water service.

(2) **Polyethylene Encasement:** The ductile-iron pipeline and fittings shall be encased in polyethylene film in accordance with the following requirements of ANSI A21.5, AWWA C105:

(a) Polyethylene:

(i) The polyethylene film shall be manufactured of virgin polyethylene material conforming to the requirement of ASTM D-1248. The raw materials shall be Type 1, Class A (natural) or C (Black) Grade E-1 with flow rate of 0.4 maximum of dielectric strength of 1015 ohm-cm^3 minimum.

(ii) The finished polyethylene film shall have a minimum nominal thickness of 0.008-inch (8 mil), and the minus tolerance on thickness shall not exceed 10 percent of the nominal thickness. The film shall have a minimum tensile strength of 1200 pounds per square inch (psi) with an elongation of 300 percent minimum. The dielectric strength shall be 800-volts/mil thickness minimum.

(b) Tube Size or Sheet Width: Table 9-5, "Tube Size and Sheet Width for Pipe Diameter," shows the tube size or sheet width for each pipe diameter.

Table 9-5: Tube Size and Sheet Width for Pipe Diameter

Nominal Pipe Diameter (Inches)	Flat Tube	Minimum Sheet Width (Inches)
4"	16"	32"
6"	20"	40"
8"	24"	48"
10"	27"	54"
12"	30"	60"
14"	34"	68"
16"	37"	74"
18"	41"	82"
20"	45"	90"
24"	54"	108"

(C) Thrust Restraint

Where designated by the Engineer with expertise in thrust restraint systems, or where existing conditions do not permit the use of concrete thrust blocks, individual joint restraint systems shall be provided as follows:

(1) **Alternative A:** Full length tie rods between joints. "Star" systems fabricated from "Cor-Ten" steel or equal according to the requirements of ASTM A-242 with a minimum yield

stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings.

(2) **Alternative B:** Pacific States Lock Mechanical Joint with Tyton Joint Core or equivalent. Assembly of the Tyton Joint portion of the product shall be in accordance with AWWA C600-77. Fittings with the joint restraint feature shall be ductile iron and shall conform to ANSI Standard A21.10. Push-on joints for such fittings shall be in accordance with AWWA Standard A121.11.

(3) **Alternative C**

(a) Follower gland type systems may be used for 12-inch diameter pipe and smaller. Pipe clamps shall be fabricated from "Cor-Ten" steel or equivalent according to the requirements of ASTM A-242 with a minimum yield stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings. The follower gland shall be manufactured of ductile iron conforming to ASTM A536. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to AWWA C111 and C153.

(b) The restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. Twist-off nuts, sized the same as tee head bolts, shall be used to insure proper actuating of restraining devices. When the nut is sheared off, a standard hex nut shall remain. The device shall have a working pressure of at least 200-psi with a minimum safety factor of 2:1.

(c) Follower gland joint restraint devices shall be of the type listed below:

(i) "EBAA Iron, Inc.," Megalug 1100 Series (4"-12")

(ii) "Uniflange,"1400 Series (4"-12")

(D) Connections to the Existing System

(1) **System Operation:** Operation of the existing system must at all times remain under the control of the Director. The contractor shall operate no valves or hydrants on the system without permission from the Director.

(2) **Connections:** All points at which the existing water systems are to be disconnected and connected to the new mains must be shown on the approved drawings.

(3) **Utility Service Interruptions:** The contractor shall take all precautions necessary to minimize interruption of all utility services and will be responsible for the restoration of the affected service. The contractor shall schedule existing valve locates with the Director at least 3 days before scheduling a shutoff.

(4) Unless otherwise specified, at any time a customer on the existing system will be deprived of a supply of water, the contractor shall advise such customer in writing 48 hours in advance of when the supply will be disconnected and reestablished.

(E) Execution

(1) **Installation of Ductile Iron Pipe:** Except as specified herein or unless specifically authorized by the Director, all installation of pipe shall conform to the recommendations contained in "A Guide for Installation of Ductile-Iron Pipe," published by the Ductile Iron Pipe Research Association. The contractor shall assure that a copy is available at the job site.

(a) Pipe Laying

(i) Pipe shall be laid with bell ends facing in the direction of laying, unless directed otherwise by the Director. Pipe shall be laid on the bedding with support over the full length of the pipe barrel.

(ii) Table 9-6, "Ductile Iron Pipe Deflection," shows the maximum allowable pipe joint deflections.

(iii) The information in the columns referring to the deflection and the approximate radii shall be adjusted for pipe lengths different than 18-foot lengths. Shorter pipe lengths will be required if a shorter radius is called for on the approved construction plans. Double hubs may be used to lay pipelines on curved alignment.

Table 9-6: Ductile-Iron Pipe Deflection

	Approximate Radius of Curve Produced by:		
Size of Pipe (inches)	**Bend in One Joint (%)**	**Deflection in One 18-Foot Length (Inches)**	**Succession of 18-Foot Joints (Feet)**
4	4	15	250
6	4	15	250
8	4	15	250
10	4	15	250
12	4	15	250
14	2	7.5	510
16	2	7.5	510
18	2	7.5	510
20	2	7.5	510
24	2	7.5	510

(iv) Vertical deflections shall not exceed any of the above values.

(v) When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Director.

(vi) The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or cement lining so as to leave a smooth end at right angles to the axis of the pipe. The flame cutting of pipe by means of an oxyacetylene torch will not be allowed. The pipe end shall be beveled and free of sharp edges that could damage the gasket during installation.

(b) Mechanical Joints

(i) The last 8 inches of the pipe spigot and the inside of the bell of the mechanical joint shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter from the joint, and then painted with a soap solution made by dissolving ½ cup of granulated soap in one gallon of water. The cast-iron gland shall then be slipped on the spigot

end of the pipe with the lip extension of the gland toward the spigot end. The gasket shall be painted with the soap solution and placed on the spigot end of the pipe to be laid, with the thick edge toward the gland.

(ii) The entire section of the pipe being laid shall be pushed forward to seat in the spigot end of the bell of the pipe in place. The gasket shall then be pressed into place within the bell, being careful to have the gasket evenly located around the entire joint. The cast-iron gland shall be moved along the pipe into position for bolting, all of the bolts inserted, and the nuts screwed up tightly with fingers. All nuts shall then be tightened with a suitable (preferably torque-limiting) wrench. The range of torque for various sizes of bolts shall be as follows:

Range of Torque	
Size (Inches)	**Torque (Ft-Lb)**
5/8	45-60
3/4	75-90
1	100-120
1-1/4	120-150

(iii) Nuts spaced 180 degrees apart shall be tightened alternately to produce an equal pressure on all parts of the gland.

(c) Push-On Joints: For push-on joints, the exterior 4 inches of the pipe at the spigot end and the inside of the adjoining bell and particularly the groove for the gasket shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter. The proper gasket supplied with the pipe shall be placed in the bell as described by the pipe manufacturer so it will spring into its proper place inside the pipe bell. A thin film of the pipe manufacturer's joint lubricant shall be applied to the gasket over its entire exposed surface. The spigot end of the pipe shall then be wiped clean and inserted into the bell to contact the gasket. Then the pipe shall be forced all the way into the belt by crowbar, or by jack and choker slings. The location of the gasket shall be checked with a gauge or tool designed for that purpose to assure that the gasket is in the proper position.

(d) Installation of Polyethylene Encasement

(i) The polyethylene encasement shall prevent contact between the pipe and the surrounding backfill and bedding material, but is not intended to be a completely air and watertight enclosure. Overlaps shall be secured by the use of 2-inch wide, 10 mil thick, polyethylene pressure sensitive tape.

(ii) The polyethylene wrap tubing shall be cut to provide for at least 1 foot of lap over both the adjoining pipes. The ends of the tubing shall be wrapped using 3 circumvential turns of tape.

(iii) The loose wrap on the barrel is to be pulled snugly around the barrel of the pipe and the excess folded over at the top. This fold will be held in place by means of 6-inch strips of the tape placed at intervals of 3 feet along the pipe barrel.

(iv) All fittings, bends, reducers, and offsets shall be wrapped in the same manner as pipe.

(v) Valves shall be wrapped by bringing the tube wrap on the adjacent pipe over the bells of the valve and sealing with tape. The valve bodies are then wrapped with flat sheets passed under the valve bottom and brought up around the body to the stem and fastened with the tape.

(2) **Installation of Thrust Restraint**

(a) Thrust blocks shall be poured between undisturbed solid ground and the fitting to be anchored. The area of bearing on the undisturbed trench wall shall be that shown on the thrust block detail or directed by the Director. The concrete shall be placed so that the pipe or fitting joints will be accessible for repair. A bond breaker shall be placed over the fitting before placing concrete.

(b) Full length tie rods between joints with pipe clamps shall be assembled using clamps on each side of pipe bells with tie rods extending the full pipe length for the dimensions shown on the drawings each direction from the restrained fitting, valve or joint. Clamps shall be installed tight enough to prevent twisting around the pipe. A washer shall be used at each clamp and tie rods shall be located on each side of the pipe. The tie rod nut should first be hand tightened with a 12-inch wrench (approximately 50 to 100 foot-pounds torque). Threaded tie rods shall extend two full threads past each nut in the final position.

(c) Follower gland type joint restraint systems shall be assembled according to manufacturer's instructions.

(3) **Testing:** Testing of ductile iron pipe shall be as specified in Section 9.12, "Testing of Water Pipes," of these Standards.

(4) **Backfilling and Restoring Surface Conditions:** Surface conditions shall be backfilled and restored as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(5) **Disinfecting Potable Pipelines:** Ductile iron pipe shall be disinfected as specified Section 9.11, "Disinfecting Waterlines," of these Standards.

9.04 Polyvinyl Chloride (PVC) Pressure Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of polyvinyl chloride (PVC) pressure pipe and appurtenances for potable water mains, water services and fire lines in the pipe diameter size range of 4" to 12".

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **PVC Pressure Pipe**

(a) PVC pressure pipe shall be similar and equal to Class 200, and shall conform to AWWA C900, "Polyvinyl Chloride (PVC)" Pressure Pipe, 4 inch through 12 inch,

for Water. All Class-200 pipe shall meet the dimension requirements of DR14 and shall have an equivalent cast-iron pipe outside diameter.

(b) Unless otherwise specified the pipe joint shall be the “push-on” type, made from clean, virgin, NSF Approved Class 12454-A or 12454-B PVC conforming to requirements of ASTM D1784 (latest revision).

(c) Provisions must be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. Pipe shall be supplied in laying lengths of 20 feet. All pipe and fittings shall be assembled with a non-toxic lubricant. Each length of pipe shall have marked on the exterior the following:

(i) Nominal size and OD base;

(ii) Material Code Designation;

(iii) Dimension Ratio number “DR 14" (iv) AWWA Pressure Class “PC 200;"

(v) AWWA Designation, AWWA C900;

(vi) Name or Trademark of Manufacturer; and

(vii) National Sanitation Foundation Seal for Potable Water

(d) The fittings shall be ductile-iron or cast-iron conforming to the requirements set forth in ANSI A21.10, AWWA C110. Cast-iron fittings 12-inch size and smaller shall be Class 250. The interior of the fittings shall be cement-mortar or epoxy lined with a 1 mil bituminous exterior coating. The fittings shall have mechanical joints in accordance with ANSI A21.11, AWWA C111. The gaskets for the joints shall be suitable for potable water service.

(2) **Polyethylene Encasement**

(a) All pipeline fittings and appurtenances shall be encased in polyethylene film in accordance with the following requirements of ANSI A21.5, AWWA C105.

(b) The finished polyethylene film shall have a minimum nominal thickness of 0.008-inch (8 mil), and the minus tolerance on thickness shall not exceed 10 percent of the nominal thickness. The film shall have at least 1200-psi tensile strength of with an elongation of 300 percent minimum. The dielectric strength shall be at least 800 volts per mil thick.

(3) Tracer Cable: Tracer wire shall be Type THHN, AWG size #12, UL listed with a single copper conductor, PVC insulation, and nylor jacket. Test stations at fire hydrants shall be CP Test Services, Glenn Series Glenn-4 with locking lid, 3½ x 4”, or approved equal.

(C) Thrust Restraint

(1) Where designated by the Engineer with expertise in thrust restraint system, or where existing conditions do not permit the use of concrete thrust blocks, individual joint restraint systems shall be provided as follows:

(a) Alternative A: Full length tie rods between joints. “Star” systems fabricated from “Cor-Ten” steel or equal according to the requirements of ASTM A-242 with a minimum yield stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings.

(b) Alternative B: Follower gland type systems may be used for 12 inch diameter pipe and smaller. Pipe clamps shall be fabricated from “Cor-Ten” steel or equal

according to the requirements of ASTM A-242 with a minimum yield stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings. The follower gland shall be manufactured of ductile iron conforming to ASTM A536. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to AWWA C111 and C153.

(c) The restraint mechanism shall consist of either numerous individually activated gripping surfaces to maximize restraint capability, or a series of machined serrations designed to grip the entire pipe surface. Twist-off nuts, sized the same as tee head bolts, shall be used to insure proper actuating of restraining devices. When the nut is sheared off, a standard hex nut shall remain. The device shall have a working pressure of at least 200 psi with a minimum safety factor of 2:1.

(d) Follower gland type joint restraint devices shall be of the type listed below:

(i) "EBAA Iron, Inc." Megalug 2000 PV Series (4"-12")

(ii) "Uniflange" 1300 and 1390 Series (4"-12")

(D) Connections to the Existing System

(1) **System Operation:** Operation of the existing system must at all times remain under the control of the Director. The contractor shall operate no valves or hydrants on the system without permission from the Director.

(2) **Connections:** All points at which the existing water systems are to be disconnected and connected to the new mains must be shown on the approved construction plans.

(3) **Utility Service Interruptions:** The contractor shall take all precautions necessary to minimize interruption of all utility services and will be responsible for the restoration of the effected service. The contractor shall schedule existing valve locates with the Director at least 3 days before scheduling a shutoff.

(4) **Customer Notification:** Unless otherwise specified, at any time a customer on the existing system will be deprived of a supply of water, the owner-developer-contractor shall advise such customer in writing 48 hours in advance of when the supply will be disconnected and when the supply will again be available.

(E) Execution

(1) **Installation of PVC Pressure Pipe:** Unless specifically authorized by the Director, all pipe shall be installed as follows:

(a) Pipe Laying

(i) Pipe shall be laid with bell ends facing in the direction of laying. No deflection in the joints shall be allowed. Whenever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or to plumb valve operators, the pipe itself may be uniformly curved as shown in Table 9-7, "Pipe Laying."

Table 9-7: Pipe Laying

Approximate Pipe Size	Offset in 20-Foot Length	Radius of Curve

(Inches)	(Inches)	(Feet)
4”	15”	120’
6”	15”	160’
8”	15”	250’
10”	15”	300’
12”	15”	400’

(ii) Pipe deflection for curvature shall not be permitted at temperatures less than 32° F ambient temperature.

(iii) When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Director.

(iv) The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. The flame cutting of pipe by means of an oxyacetylene torch will not be allowed. Bevel the end of the pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field cut pipe.

(v) Tracer wire shall be attached to the pipe as shown in Chapter 11, “Technical Drawings,” of these Standards.

(b) Mechanical Joints: The outside of the spigot and the inside of the bell shall be wiped thoroughly clean. Set the rubber ring in the bell with the marked edge facing toward the end of the bell. Lubricate the spigot end using a thin film of the manufacturer-supplied lubricant. Push the pipe spigot into the bell manually, with blocking and bar, or with special jacks. Position the completed joint so that the mark on the pipe end is in line with the end of the bell. Pipe joint shall not be assembled using power or trenching equipment.

(c) Push-On Joints: For push-on joints, the exterior 4 inches of the pipe at the spigot end and the inside of the adjoining bell and particularly the groove for the gasket shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter. A thin film of the pipe manufacturer’s joint lubricant shall be applied to the gasket over its entire exposed surface. The spigot end of the pipe shall then be wiped clean and inserted into the bell to contact the gasket. Then the pipe shall be forced all the way into the bell by crowbar, or by jack and choker slings. The location of the gasket shall be checked with a gauge or tool designed for that purpose to assure that the gasket is in the proper position.

(d) Installation of Polyethylene Encasement

(i) The polyethylene encasement shall prevent contact between the pipe fittings and the surrounding backfill and bedding material, but is not intended to be a completely air and watertight enclosure. Overlaps shall be secured by the use of 2-inch wide, 10 mil thick, polyethylene pressure sensitive tape.

(ii) The polyethylene wrap tubing shall be cut to provide for at least 1 foot of lap over both the adjoining pipes. The ends of the tubing shall be wrapped using 3 circumvential turns of tape.

(iii) The loose wrap on the barrel is to be pulled snugly around the barrel of the fitting and the excess folded over at the top. This fold will be held in place by means of two, 6- inch strips of the tape.

(iv) Valves shall be wrapped by bringing the tube wrap on the adjacent pipe over the bells of the valve and sealing with tape. The valve bodies are then wrapped with flat sheets passed under the valve bottom and brought up around the body to the stem and fastened with the tape.

(2) **Installation of Thrust Restraint**

(a) Thrust blocks shall be poured between undisturbed solid ground and the fitting to be anchored. The area of bearing on the undisturbed trench wall shall be that shown on the thrust block detail or directed by the Director. The concrete shall be placed so that the pipe or fitting joints will be accessible for repair. A bond breaker shall be placed over the fitting before placing concrete.

(b) Full length tie rods between joints with pipe clamps shall be assembled using clamps on each side of pipe bells with tie rods extending the full pipe length for the dimensions shown on the drawings each direction from the restrained fitting, valve or joint. Clamps shall be installed tight enough to prevent twisting around the pipe. A washer shall be used at each clamp and tie rods shall be located on each side of the pipe. The tie rod nut should first be hand tightened with a 12-inch wrench (approximately 50-100 foot-pounds torque). Threaded tie rods shall extend two full threads past each nut in the final position.

(c) Follower gland type joint restraint systems shall be assembled according to manufacturer's instructions.

(3) **Installation of Tracer Cable:** Tracer wire shall be spirally wrapped around the pipe exterior, 2 wraps minimum per 20-feet of pipe, as it is installed in the trench or taped to the top of the pipe. Splices due to breaks in wire continuity shall be made by stripping insulation coating from each wire with wire stripper pliers. Wires shall be joined with a solderless connector, 3M Direct Bury Splice Kit or approved equivalent, in accordance with manufacturers instructions. The solderless connector shall be covered with Emmerson Electric Seal-A-Conn II putty or approved equal.

The wire shall form a continuous electrical circuit between any 2 contact points on the new pipeline, including branch lines and fire hydrant laterals. Wire shall be stubbed out to the point where the new pipe connects to the existing main unless otherwise directed by the Director. Where the wire terminates at a point where there is not an installed wire, the ends of the wire shall be stripped bare a minimum of 18-inches and grounded into the native soil material. Special care should be taken to avoid contact from the tracer wire to steel gas service lines.

(4) **Testing** Testing of PVC pressure pipe shall be as specified in Section 9.12, "Testing of Water Pipes," of these Standards.

(5) **Backfilling and Restoring Surface Conditions:** Shall be as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(6) **Disinfecting Potable Pipelines:** PVC pressure pipe shall be disinfected as specified Section 9.11, "Disinfecting Waterlines," of these Standards.

9.05 Water Services

(A) General

(1) **Scope:** This section describes the furnishing and installation of water services and fire lines in the pipe diameter size range of 3/4 to 2 inches. For water services and fire lines greater than 2 inches in diameter refer to Section 9.03, "Ductile Iron Pipe," Section 9.04, "Polyvinyl Chloride (PVC) Pressure Pipe," Section 9.06, "Gate Valves," and Section 9.08, "Tapping Sleeves and Valves," of these Standards.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Pipe:** Pipe shall be Type K copper, soft drawn, in accordance with ASTM B88.

(2) **Fittings:** Use flared fittings to match pipe such as "Mueller" H-15400, "Ford" C22, or approved equivalent. Use bends such as "Mueller" H-15525, "Ford" L22, or approved equivalent.

(3) **Corporation Stops:** Corporation stops shall be "Mueller" H-15000, "Ford" F600, or approved equivalent.

(4) **Water Meters:** Water meters, meter pit and cover, interior piping and yoke shall be purchased from the City of Boulder.

(5) **Service Saddles:** Corporation stops require the installation of a double strap bronze service saddle, similar and equivalent to "Rockwell" No. 323, with PVC pipe or brass service saddles similar and equivalent to "Ford" No. S90. No direct taps to PVC pipe shall be allowed.

(6) **Insulators (Ferrous Pipes only):** Insulators shall be installed at the inlet end of the corporation stop and shall be Ford Service Insulators or an approved equivalent for service lines.

(C) Execution

(1) **General**

(a) Size as shown, lay to grades and lines in accordance with pipe manufacturer's specifications. Thoroughly clean pipe interiors of foreign matter before placing into trench. Replace with new pipe any laid section of pipe found damaged or defective. All pipe fittings, valves, and appurtenances shall be installed according to manufacturer's instructions. Corporation stops shall be installed with the appropriate tapping machine in the presence of the Director after the waterline has been pressure tested.

(b) All bedding, pipe zone backfill, compaction, polyethylene sheathing and other details of the water pipeline construction shall be returned to original condition after service connections are completed.

(c) Service connections to all ferrous mains shall be electrically insulated by means of a City approved insulating fitting.

(2) **Pipe Cutting: Cutting** shall be done neatly by methods that will not damage pipe.

(3) **Water Meters:** Water meters shall be installed as indicated in Chapter 11, "Technical Drawings," of these Standards for all water services. Before water meters are installed, the Director will determine the location for their placement.

(4) **Testing:** Testing of water service pipe shall be as specified in Section 9.12, "Testing of Water Pipes," of these Standards.

(5) **Backfilling and Restoring Surface Conditions:** Backfilling and Restoring surface conditions shall be as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(6) **Disinfecting Potable Pipelines:** Water service pipe shall be disinfected as specified Section 9.11, "Disinfecting Waterlines," of these Standards.

9.06 Gate Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of gate valves and appurtenances for potable water service in the pipe diameter size range of 4 to 12 inches.

(2) **Quality Assurance**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) All valves shall be tested in accordance with AWWA C500 or C509. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

(1) **Gate Valves:** Gate valves shall be iron-bodied, resilient seat or epoxy coated double disc, with non-rising stem conforming to AWWA C500 or C509. Valves shall open counterclockwise and shall be rated for a design working pressure of 200 psi. Double disc type valves shall be bronze mounted with parallel seats. All buried valves shall have one 2-inch square operating nut. Mechanical or push-on joints appropriate for buried installations shall be provided. Where valves are installed at tee connections, a swivel adaptor shall be used to restrain the valve to the tee. Bolts, studs, and nuts shall be cadmium-plated or zinc-coated.

(2) **Extension Stems**

(a) Extension stems with a 2-inch square operating nut and a support for the upper end of the extension shall be provided for all valves installed more than 5 feet deep. The operating nut shall be located within 5 feet of the finished grade. Extension stems shall be mechanically connected to the operating nut. Extension stems shall be fabricated from solid steel shafting not smaller in diameter than the stem of the valve or from galvanized steel pipe having an ID not smaller than the OD of the valve stem. Extension stems shall be connected to the valve by a flexible socket type coupling. All connections shall be pinned, keyed, or socket type. Pipe couplings will not be acceptable.

(b) Each extension stem for a buried valve shall extend to within 6 inches of the ground surface, shall be provided with spacers that will center the stem in the valve box, and shall be equipped with a wrench nut.

(3) **Valve Boxes**

(a) All buried valves shall be provided with valve boxes. Valve boxes shall be of cast iron, 3 piece screw type, suitable for the depth of cover required by the drawings. Valve boxes shall be 5 ½inches in diameter, shall have a minimum thickness at any point of 1/16 inch, and shall be provided with suitable cast iron bases and stay-put covers. Covers shall have cast thereon “water” on the top. They shall be Tyler 6860 series or approved equal.

(b) The valve box shall have at least 6 inches adjustment above and below specified depth of cover over pipe.

(c) All parts of valve boxes, bases, and covers shall be coated by dipping in bituminous varnish.

(d) Valves and valve boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves, with the top of the box brought flush with the finished grade. After being placed in proper position, earth shall be filled in around each valve box and thoroughly tamped on each side of the box.

(4) **Special Wrenches and Keys:** All tools needed to operate valve and to open valve box lid. At least one of each type as required for each style and size of box and lid shall be furnished by the contractor. Provide 1 key for each valve. Key lengths shall be as approved by the Director.

(C) Execution

(1) **Handling:** All valves and actuators shall be transported and stored in a manner that will protect them from damage.

(2) **Installation:** Install valves as indicated in Chapter 11, "Technical Drawings," of these Standards, and set plumb on a firm base. All foreign matter shall be removed from the valve interior prior to installation.

(3) **Valve Boxes:** Install a valve box over the gate valve with the base section centered over the operating nut and resting on well-compacted backfill. The top section shall be so set as to allow equal movement above and below finished grade, with the final elevation to be 1/4 inch below finished grade in roadways and 1 to 2 inches above grade outside of roadways. The top of base section shall be placed approximately on line with the operating nut at the top of the valve stem, and the entire assembly shall be plumb.

(4) **Tests:** Gate valve tests shall be with and part of the general tests on the companion water lines.

(5) **Disinfection:** Gate valve disinfection shall be done with and as a part of the disinfection to the companion water lines.

9.07 Butterfly Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of gate valves and appurtenances for potable water service in the pipe diameter size range of 12 inches to 24 inches.

(2) **Quality Assurance:** Manufacturer's installation recommendations and certificates of compliance shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(3) **Testing:** All valves shall be tested in accordance with Section 3.8 of AWWA C504. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

(1) **Butterfly Valves**

(a) Butterfly valves shall be rubber-seated conforming to the AWWA C504 and designed for buried service. The valves shall be designed to operate as open or closed with a design velocity of 8 feet per second. The valves shall have a cast-iron body with mechanical joint ends conforming to ANSI 21.11, AWWA C111 and shall be rated for a design working pressure of 150 psi. Valves shall be manufactured by Keystone or equal.

(b) Discs shall be cast or ductile iron with stainless steel, type 304, either stub or one piece shafts. Discs shall be secured to shafts by means of solid, smooth sided, stainless steel or monel pins or dowel pins. Each taper pin or dowel pin shall extend through or shall wedge against the side of the shaft and shall be mechanically secured in place. The use of bolts, setscrews, knurled or fluted dowel pins,

expansion pins, roll pins spring pins, or other devices in lieu of the pins specified herein will not be acceptable.

(c) Shaft bearings shall be the bushing type of nylon or Teflon. Thrust bearings that are directly exposed to line liquid and that consist of a metal bearing surface in rubbing contact with an opposing metal bearing surface will not be acceptable. Shaft seals may be rubber ring or chevron packing.

(d) Seats shall be rubber vulcanized to the body and designed to provide bubble tight shutoff with mating surface of Type 304 or 316 stainless steel or monel mounted on the discs. Valve seat configurations that rely on the mating pipe flange to hold the seat in position in the valve body will not be acceptable.

(e) The valve operator shall be the traveling-nut type designed for previous stated conditions, in an enclosed body, sealed to prevent the entrance of groundwater up to the depth of 5 feet above the valve. The operator shall have travel limiting devices to prevent over closing or opening damage to the valve. Valves shall open counterclockwise with the use of a valve key on a 2-inch square operating nut. The housing of traveling-nut type actuators shall be fitted with a removable cover that shall permit inspection and maintenance of the operating mechanism without removing the actuator from the valve.

(f) Extension stems, valve boxes and special wrenches and keys shall be as specified in Section 9.06(B), "Materials," of these Standards.

(C) Execution

(1) **Handling:** All valves and actuators shall be transported and stored in a manner that will protect them from damage.

(2) **Installation:** Install valves with the shaft horizontal according to the manufacturer's recommended installation procedures. Operate all valves from full open to full close before installation. Check all seats, seat rings, shaft sleeves, disc connections, etc. prior to installation.

(3) **Valve Boxes:** Install valve boxes over the valve operator with the base section centered over the operator nut and resting on well-compacted backfill. The top section shall be set to allow equal movement above and below finished grade, with final elevations to be 1/4 inch below finished grade in roadways and 1 inch to 2 inches above grade outside of roadways. The top of base sections shall be placed approximately on line with the operator nut at the top of the valve stem, and the entire assembly shall be plumb.

(4) **Tests:** Butterfly valve tests shall be done with and as a part of the general tests on the companion water lines.

(5) **Disinfection:** Butterfly valve disinfection shall be done with and as a part of the general disinfection to the companion water line.

9.08 Tapping Sleeves and Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of tapping sleeves and valves for potable water service in the pipe diameter size range of 4 inches to 12 inches.

(2) **Quality Assurance**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) The manufacturer of tapping sleeves and valves shall be experienced in their design and construction, shall be regularly engaged in their manufacture, and shall have produced tapping sleeves and valves of the sizes specified herein that have given successful service for a period of at least 5 years.

(B) Materials

(1) **General**

(a) All steel plate used in fabrication of the tapping sleeves shall conform to ASTM Designation A 36 or A 285, Grade C. Tapping sleeves shall be Mueller "No. H-615" or equivalent for standard pipes and Ford "FTSS" or equivalent for oversized pipes

(b) Extension stems, valve boxes, and special wrenches and keys shall be as specified in Section 9.06(B), "Materials," of these Standards.

(2) **Flanges:** Flanges shall be fabricated from steel plate, and all dimensions shall conform to AWWA Standard C207, Class D. Flanges shall be machined to a flat rate with finish of 250 micro inches or machined to a flat surface with a serrated finish in accordance with AWWA Standard C207. In addition, the machined face shall also be recessed for tapping valves in accordance with the MSS Standard SP-60.

(3) **Gaskets:** Gaskets shall be compounded from new materials, and the shape and cross-section of the gasket shall provide adequate seal for the design pressure. Gaskets shall be shop glued to the groove provided in the body section.

(4) **Fasteners:** Bolts and hex nuts shall be Stainless Steel, "Usalloy", "Dresserloy", "Cor-Ten" or an approved equivalent for corrosion control.

(5) **Testing Outlet:** A 3/4 inch NPT by welded coupling shall be attached to the outlet nozzle of each tapping sleeve assembly, complete with a 3/4 inch square head pipe plug.

(6) **Tapping Valves:** With the exception of the valve ends and other modifications necessary for tapping service, tapping valves shall be as specified in Section 9.06(B), "Materials," of these Standards. Each tapping valve shall be provided with a flanged inlet end designed, faced and drilled for attachment to the outlet flange of the tapping sleeve; an outlet end provided with a tapping flange for attachment of a standard drilling machine; and a mechanical joint bell end for connection of the branch main. The size of the waterway shall include the appropriate clearance for the diameter of the tapping machine cutter recommended by the valve manufacturer. Tapping valves shall be Mueller "No. H-667" or equal.

(7) **Painting:** All ferrous metal surfaces of tapping sleeves, valves and accessories, both interior and exterior, shall be shop painted for corrosion protection. The valve manufacturer's standard paint will be acceptable provided it is functionally equivalent to the specified paint and is compatible with the specified field painting.

(a) Materials:

(i) Asphalt Varnish: Fed. Spec TT-V-51;

(ii) Coal Tar: Koppers "Bitumastic Super Tank Solution;"

(iii) Epoxy: Mobil “78-D-7 Tank Lining Epoxy;”

(iv) Rust Preventative: Houghton “Rust Veto 344;” or

(v) Rustoleum Compound “R-9."

(b) Surfaces to be painted:

(i) Unfinished Surfaces;

(ii) Interior: Asphalt varnish (two coats), coal tar or epoxy;

(iii) Exterior (Buried or Located in Manholes): Asphalt varnish or coal tar;

(iv) Polished or Machined Surfaces: Rust preventative compound; and

(v) Operators and Accessories: Rust inhibitive primer.

(C) Execution

(1) **Tapping Valves:** Install tapping valves in the lines as indicated on the drawings, and set plumb on a firm base. All foreign matter shall be removed from the valve interior prior to installation. Valves shall be securely bolted to the tapping sleeve in accordance with the manufacturers instructions using the fasteners specified in Subsection 9.08(B)(4), above.

(2) **Tests:** Valve tests shall be done with and as a part of the general tests on the companion waterlines.

(3) **Disinfection:** Valve disinfection shall be done with and as a part of the general disinfection to the companion waterline.

9.09 Fire Hydrants

(A) General

(1) **Scope:** This section describes the furnishing and installation of fire hydrants for potable water service.

(2) **Quality Assurance**

(a) Manufacturer’s certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) All valves shall be tested in accordance with Section 5.1 of AWWA C502. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

Hydrants may be purchased from the City of Boulder Fire Department, and shall be Mueller Centurion A-423, with mechanical joint bottom connection and shall comply with AWWA C502 having the following requirements:

(1) **Inlet Pipe:** 6 inch, mechanical joint inlet shoe and accessories

(2) **Trench Depth:** 4-1/2 feet cover, minimum

(3) **Operating Nut:** 1-5/8 inch pentagon

(4) **Open:** Left (CCW)

(5) **Connection:** Two 2-1/2 inch hose nozzles and one 4-1/2 inch pumper nozzle

(6) **Threads:** National Standard Hose Threads

(7) **Pressure:** 150 psi working pressure, 300 psi pressure

(8) **Break-Off Flange:** Hydrants shall be provided with traffic break-off flange.

(9) **Color:** Color shall be Rustoleum No. 831 "restful green" except for bonnet, weather caps and nozzle caps, which must be Rustoleum No. 2766 "reflectorized white."

(10) **Spare Parts:** A set of spare break-off parts shall be furnished.

(C) Execution

(1) **Hydrants:** Where applicable, hydrants shall be installed with pumper outlet facing the adjacent roadway or parking area. Set hydrants at such elevations that the connecting pipe shall drain to the main with a grade of not less than 1 percent, and upon a concrete foundation not less than 6 inches thick and 18 inches square. The centerline of nozzles shall be at least 18 inches above finished grade. Firmly block the back of the hydrant opposite the pipe connection with a concrete thrust block braced against the vertical face of the trench to prevent the hydrant from blowing off the line.

(2) **Drainage Aggregate and Backfill:** Place not less than 1/3 cubic-yard of approved clean gravel or crushed rock around the base of each hydrant and 12 inches over the top of the supply pipe to insure drainage. A layer of 30-pound asphalt-saturated felt paper or heavy vinyl sheet shall be placed over gravel to keep backfill material from sifting into gravel. Thoroughly compact the backfill around hydrants, to the grade line, in an approved manner.

(3) **Operations Check:** Clean hydrant interiors of all foreign matter before installation. Stuffing boxes shall be tightened and the hydrant inspected in opened and closed positions to see that all parts are in working condition.

(4) **General:** Hydrants shall be tagged "out-of-service" until the water system is operational. It is the responsibility of the contractor to notify Boulder Police Communications regarding the location of the tagged hydrants.

9.10 Combination Air Valve

(A) General

(1) **Scope:** This section describes the furnishing and installation of combination air valves for potable water service.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Manholes:** Refer to Section 9.15, "Manholes and Inlets," of these Standards.

(2) **Combination Air Valve:** The valve shall be a 2-inch combination air release vacuum valve, "Clow" No. 5403-B, 250 psi, or approved equivalent. The combination air valve shall be provided with a 2-inch diameter hand wheel operated gate valve.

(3) **Hose Gate Valve:** A 3/4-inch hose gate valve is to be installed in the air release valve manhole. The valve shall have a bronze body, threaded end, solid wedge, union bonnet, inside screw rising stem gate valve. These valves shall be "Powell" 375 HS. Each hose gate valve shall be equipped with a brass cap and chain.

(4) **Ball Valve:** Ball valves shall be of bronze or brass construction with two-piece end entry body, bronze or brass ball, Teflon or Viton stem seal, reinforced Teflon seats and thrust washer, a removable operating lever, and threaded ends. Valves shall be rated not less than 500 psi non-shock cold WOG and shall be drip-tight in both directions. Valves shall be "Conbraco Industries" Apollo 70-100 Series, "Powell" Fig 4210T, or "Stockham" S-216.

(5) **Corporation Stop:** A corporation stop shall be as referenced in Subsection 9.05(B)(3), in this chapter.

(6) **Insulators:** Insulators shall be as referenced in Subsection 9.05(B)(f), in this chapter.

(C) Execution

(1) **Installation:** Install valve, manhole, and appurtenances as indicated on Drawing No. 5.22, in Chapter 11, "Technical Drawings," of these Standards, and in accordance with applicable provisions of the related sections.

(2) **Tests:** Valve tests shall done be with and as a part of the general tests on the companion waterlines.

(3) **Disinfection:** Valve disinfection shall be done with and as a part of the general disinfection to the companion waterlines.

9.11 Disinfecting Waterlines

(A) Scope

This section describes the disinfecting of all portions of the potable water system, including buried piping, valves, hydrants, and any portion of the existing connecting system that might have become contaminated during construction activities, and also any temporary water service piping used during construction.

(B) Materials

(1) **Chlorinating Material:** The chlorinating material shall either be a hypochlorite solution, tablets or granules.

(2) **Tablet Attachment:** The hypochlorite tablets shall be fastened to the top of the pipe using Permatex No. 1.

(C) Execution

(1) **Disinfection**

(a) Care shall be taken to prevent contaminating materials from entering the water mains during construction or repair. Such materials that may accidentally enter the main shall be removed by flushing. This flushing shall be done prior to disinfection unless the tablet method of disinfection is used. If, in the opinion of the Director, the contaminated material that has entered cannot be removed by flushing, the interior of the pipe shall be cleaned by mechanical means and then swabbed with a 1 percent hypochlorite solution.

(b) Upon completion of the water pipelines, all new pipe, valves, hydrants, etc. shall be thoroughly flushed and disinfected, using a continuous-feed method of hypochlorite and water mixture or hypochlorite tablets or granules in accordance with AWWA Standard C-651, latest revision.

(c) The chlorinating material shall be introduced into the water lines and distribution systems in a manner approved by the Director. After a contact period of not less than 24 hours, the treated water in the lines shall contain not less than 10 mg per liter chlorine using the continuous-feed method or 25 mg per l chlorine using the tablet or granular method throughout the length of the line. The system shall be flushed after successful completion of disinfection with clean water until the residual chlorine content is no more than 1.0 mg per liter. All valves in lines being disinfected, except those being used as bulkheads, shall be opened and closed several times during the contact period. During flushing and disinfection the contractor shall make sure that none of the disinfection solution enters any existing water main.

(d) Flushing shall be done with a flushing velocity of at least 2 ½feet per second. The contractor shall provide all fittings required to flush the line. Flushing will be accomplished in such a manner that no erosion will occur and there will be no damage to street, fish, animals, plants or other property.

(2) **Bacteriological Examination:** After the system has been thoroughly flushed and before the new water line is connected to the distribution system, samples shall be taken from representative points in the system, at intervals of 1200 feet, in sterile bottles treated with sodium thiosulfate. Labeled samples shall be submitted to the City Drinking Water Program staff, or designated certified laboratory, for bacteriological examination. Submitted samples shall meet all City and State bacteriological standards, showing the absence of both coliform and heterotrophic bacterial growths. If the initial disinfection fails to produce satisfactory bacteriological results, the new main shall be reflushed and 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.

(3) **Disposal of Solution:** Following testing, the solution and flushing water shall be disposed of by the contractor into the nearest sanitary sewer line. The solution and flushing water shall not be dumped into any lakes, streams, waterways, irrigation ditches or stormwater drainage systems. If wasted water cannot be safely discharged into a sanitary sewer system, and then a reducing agent shall be applied to the wasted water to thoroughly neutralize the chlorine residual remaining in the water.

9.12 Testing of Water Pipes

(A) General

This section describes the testing of all water pipe including water mains, fire lines and services.

(B) Materials

The contractor shall provide all necessary test equipment including test pumps, pipe, connectors, meters, gauges, instruments, and other equipment required. Pressure gauges used shall be graduated in increments no more than 5 psi and shall have a range of approximately twice the test pressure. Gauges meters and other instruments shall be calibrated prior to testing.

(C) Execution

(1) **Notification and Witness**

(a) The contractor shall notify the Director of all tests at least 48 hours prior to testing so that the Director can witness the tests.

(b) The pipe may be subjected to hydrostatic pressure and inspected and tested for leakage at any convenient time after the trench has been partially backfilled, except at the joints, or backfilled as permitted by the Director. Where any section is provided with concrete thrust blocks, the pressure test shall not be made until at least 2 days have elapsed after the concrete was installed.

(2) **Pressure Test**

(a) All new pipe shall be pressure tested prior to connection to the existing system. All pipe shall be tested at a pressure of 150 psi at the lowest point in each section or 1½ times the working pressure, whichever is greater.

(b) Prior to testing, all equipment that would be damaged by the test pressure shall be removed. This equipment shall be replaced in the system after testing is complete. All pipe and appurtenances shall be backfilled except for joints unless otherwise permitted by the Director.

(c) The contractor shall slowly fill the pipe with water prior to testing and remove all air from the piping system. Each valved section, unless otherwise directed by the Director, shall be tested prior to connection to the existing system. The duration of each pressure test shall be at least 2 continuous hours. Test time will be accrued only while full test pressure is on the system. All water used in testing the pipelines shall be provided by the contractor from a potable water source.

(d) The specified test pressure shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Director. The contractor shall furnish all necessary labor, equipment, and connection corporation stops to the pipeline to perform the test.

(e) No testing shall be permitted against valves or fittings that are part of the existing system unless specifically approved by the Director. All exposed pipes, fittings, valves, hydrants, and joints will be carefully examined during the test. Any cracked or defective pipe, fittings, valves, or hydrants discovered during the pressure test shall be removed and replaced by the contractor with sound material. The test shall be repeated until the test is satisfactory to the Director.

(3) **Leakage Test**

(a) A leakage test shall be conducted after the pressure test has been completed, unless the pressure test indicates that there are no leaks. The contractor shall furnish the pump, pipe, connections, meters and all other necessary apparatus, and shall furnish all necessary assistance to conduct the test. The duration of each leakage test shall

be two hours, and, during the test, the main shall be subjected to a hydrostatic pressure specified.

(b) No pipeline installation will be accepted until the leakage is less than the amount computed by the following formula:

$$L = \frac{SD(P)^{0.5}}{133{,}200}$$

Where: L = Allowable Leakage (Gallons Per Hour)

S = Tested Length of Pipe (Feet)

D = Nominal Diameter of Pipe (Inches)

P = Average Test Pressure During the Test (psi)

(c) The contractor shall, at their own expense, locate and repair the points of leakage until the leakage is within the specified allowance.

9.13 Polyvinyl Chloride (PVC) Non-pressure Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of polyvinyl chloride (PVC) non-pressure pipe and appurtenances for storm drains, sanitary sewer mains and sewer services in the pipe diameter size range of 4" to 15".

(2) **Quality Assurance: Manufacturer's** certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **PVC Non-pressure Pipe**

(a) PVC non-pressure pipe shall be type PSM polyvinyl chloride (PVC) having a cell classification of 12454-B or 12454-C or 13364-B (with a minimum tensile modules of 500,000 psi) as defined in ASTM D1784. All PVC pipe and fittings shall meet or exceed all of the material requirements of ASTM D3034 and thickness requirements of SDR 35.

(b) Provisions must be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. Gaskets shall conform to ASTM F477. Pipe shall be supplied in laying lengths of 19-1/2 to 20 feet. All pipe and fittings shall be assembled with a non-toxic lubricant. Each length of pipe and all fittings shall have marked on the exterior the following:

(i) Manufacturer's Name or Trademark;

(ii) Nominal Pipe Size;

(iii) PVC Cell Classification (e.f. 12454-B);

(iv) Legend - Type PSM SDR-35 Sewer Pipe; and

(v) ASTM - D3034.

(c) All fittings and plugs to be used with the PVC pipe shall be those manufactured by the manufacturer of the pipe. Each special fitting shall be a completely manufactured unit with either bells or spigots on each connection that are an exact duplication of the bells and spigots on the pipeline. Fittings with any other type of connections will not be accepted.

(2) **Plugs:** Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation without permanently sealing the joint.

(3) **Couplings**

(a) Couplings shall be used only where shown on the approved drawings or where approved in writing by the Director. The contractor shall provide a description of an exact location of any couplings used.

(b) Flexible couplings shall consist of a rubber gasket or boot, stainless steel tightening bands. The coupling shall conform to requirements of ASTM C425 and shall be "Mission" ARC or approved equivalent.

(4) **Grout**

(a) Grout shall conform to the specifications defined in Section 9.15(B)(e). The contractor may substitute a two-component, 100 percent solids epoxy resin (Sikadur Hi-Mod LV) for the specified grout.

(b) Grout used for sealing service connections shall be a 2-component, waterproof epoxy grout specifically manufactured for this application. The grout shall adhere to any of the dissimilar materials.

(5) **Sealants:** Sealants used on manholes or pipe connections shall be equal to SIKAFLEX-la, a one component polyurethane base, elastomeric sealant. When required due to moisture or immersion, provide SIKAFLEX 429 primer for application onto the substrate according to manufacturer's recommendation.

(C) Execution

(1) **General**

(a) Each pipe length and fitting interior, interior surface of bells, and exterior surface of spigots shall be cleaned of all foreign material before placement in the trench and shall be kept clean at all times thereafter. Each item shall also be examined for cracks and other defects before installation.

(b) Pipe shall be cut, only whenever necessary, to conform to location of manholes or connections. All cuts shall be straight, true, and at right angles to the axis of the pipe. The cutting process shall leave a smooth end without damaging the pipe. All burrs shall be removed from the ends of cut pipe, and the end lightly rasped or filed. All tools used in cutting pipe will be subject to the Director's approval.

(c) Pipe laying shall proceed with the spigot ends of pipe pointing in the direction of the flow, unless otherwise approved by the Director. Each pipe length shall be laid true to line and grade in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets to the flow line. Pipe shall be laid in a dewatered trench and shall not be used for draining water from the trench. Do not lay pipe when trenches or weather conditions are unsuitable for such work.

(d) Whenever the pipe is left unattended or pipe laying is not in progress, temporary plugs shall be installed at all openings. Temporary plugs shall be watertight and of such design as to prevent debris and animals from entering the pipe. All temporary plugs will be subject to approval by the Director.

(e) The contractor shall install the materials in accordance with the manufacturer's recommendations. If there is a conflict between the methods prescribed in the approved plans and the manufacturer's instructions, the contractor shall obtain resolution from the Director, before proceeding with the work.

(2) **Pipe Installation**

(a) Pipe Laying:

(i) No deflection in the joints shall be allowed. All pipe shall be fully supported along the full length of pipe barrel without support by the bell mounding.

(ii) When curved sewers are approved in the construction plans, the alignment curve shall be completed by installing the pipes on uniform curves by deflecting the pipe barrel. The minimum curves are shown in Table 9-8, "Curvilinear Sewer Pipe Laying," of these Standards.

Table 9-8: Curvilinear Sewer Pipe Laying

Pipe Diameter (Inches)	Minimum Radius (Feet)	Offset 20' Length (Inches)
4	150	16
6	200	12
8	250	10
10	300	8
12	350	7
15	400	6

(b) Pipe Joints

(i) The outside of the spigot and the inside of the bell shall be thoroughly wiped clean. Set the rubber ring in the bell with the marked edge facing toward the end of the bell. Lubricate the spigot end using a thin film of the manufacturer-supplied lubricant. Push the pipe spigot into the bell. Position the completed joint so that the mark on the pipe end is in line with the end of the bell.

(ii) Bevel the end of cut pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field-cut pipe.

(3) **Connection of Pipe to Concrete Manhole Base**

(a) The pipe shall be encased in the concrete poured for the manhole base as detailed in Drawing No. 6.01, "Standard Sewer Manhole," in Chapter 11, "Technical Drawings," in these Standards. Special provisions shall be made for water tightness of the connection.

(b) The exterior circumference of the pipe where encased in concrete for water tightness shall be uniformly roughened or scarified by sanding with coarse sandpaper or emery cloth for at least 6 inches encased length.

(c) Additionally, gasket as specified elsewhere shall be stretched onto the pipe to form a weep ring where encased in concrete. Any alteration to the above specified methods for pipe connection to concrete shall be submitted to the Director for approval.

(4) **Grouting**

(a) Any opening between the manhole wall and pipe made during construction shall be closed and sealed with watertight grout. The opening shall be of sufficient size to accommodate the pipe, "O" rings, and grout. The grout shall extend no less than the full width of the manhole barrel.

(b) Channels that have been cut into concrete bases shall be smoothed to the specified contour with grout. The grout shall extend no less than the full width of the manhole barrel.

(5) **Temporary Plugs:** Where required on construction plans and at the end of each sewer service stub out, the pipe shall be sealed with a removable plug. Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation without permanently sealing the joint.

(6) **Sewer Services:** The general location of the sewer service lines is detailed in Drawing No. 6.06, "Sewer Service Line," in Chapter 11, "Technical Drawings," in these Standards. Actual locations of the service lines shall be determined by the approved construction plans and in the field by the Director. The contractor shall notify the Director prior to constructing each sewer main so that the Director may have adequate time to determine the final location of each service tee or wye fitting to be installed in the sewer main. Failure of the contractor to properly notify the Director as noted above may result in the contractor's removal of any portion of the sewer main that is necessary to install the fittings in their proper location as determined by the Director.

(a) The contractor will be allowed to tap and install a service saddle to new sewer mains only at those locations approved by the Director. Connections onto sewer mains shall be made only by boring or drilling with equipment designed for this purpose. Connections shall not be made by impact equipment. The contractor shall request, in writing, Director approval of methods and equipment proposed to be used for performing connections.

(b) The contractor shall remove from the sewer main all debris created by making connections before the service line is connected.

(c) Service line saddle connections shall be attached to the sewer main with an epoxy-bonding agent. The bonding agent shall be applied to a clean, dry surface. The connection shall remain dry until the bonding material has set, depending upon environmental conditions. Backfill around the connection shall not be attempted until the material has hardened and been accepted by the Director.

(d) At the end of all sewer services, the contractor shall provide plugs and furnish and set two marker posts. One marker post shall be buried at least 3 feet and shall extend at least 2 feet above the ground surface and shall have a piece of green flagging at the top or be painted green. The second marker shall extend from the

end of the service to 18 inches below the existing surface. The marker posts shall be wood 2 x 4, 4 x 4 or #4 rebar.

(7) **Backfilling and Restoring Surface Conditions:** Shall be as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(8) **Testing** Testing of PVC non-pressure pipe shall be as specified in Section 9.16, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

9.14 Reinforced Concrete Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of reinforced concrete pipe and appurtenances for culverts, storm drains and sewers in the pipe diameter size range of 12 inches to 144 inches.

(2) **Quality Assurance:**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) The pipe will be tested by the manufacturer based on the three-edge bearing test for both the 0.01 inch crack and the ultimate strength as set forth in ASTM C-497. The pipe shall be tested at the manufacturer's plant. Not more than 1 percent of the number of pipe lengths, but no fewer than two pipes, for each size of pipe, will be tested. The contractor shall provide copies of the test results to the Director for approval. The Director may select pieces to be tested.

(B) Materials

(1) **Reinforced Concrete Pipe**

(a) The reinforced concrete pipe shall comply with the requirements of ASTM C76. The pipe shall be Class III unless noted otherwise on the approved construction plans. The cement for the pipe shall conform to the requirements set forth in ASTM 150 and shall be type II and shall have a minimum compressive strength of 4,000 psi. All wall thicknesses shall be those established in "Wall B" in table 3, of said C76 specification, and the reinforcement shall be shown in the same "Wall B." Each section, or "stick", of pipe shall be 7 feet-6 inches or greater in length.

(b) No elliptical reinforcement will be permitted except for any elliptical reinforced concrete pipe designated on the construction plans.

(c) Lifting holes will not be permitted in any of the pipe. The following shall be clearly marked on the exterior surface of the pipe:

(i) ASTM Specification;

(ii) Date of manufacture;

(iii) Class and size; and

(iv) Name or trademark of manufacturer.

(d) The joint design shall be tongue and groove, or bell and spigot. Joints for the circular reinforced concrete pipe shall be all rubber gasket conforming to ASTM C-443, latest revision. The gasket shall be attached to the spigot of the pipe and shall make the joint flexible and watertight. The contractor may use butyl mastic joint sealant in rope or trowel applied form in lieu of rubber gaskets for circular pipe if approved in writing by the Director. For all non-circular pipe and culverts, butyl mastic joint sealant may be used. The contractor shall submit test results and material specifications on the sealant to the Director before the Director gives written approval of its use. This sealant shall be made specifically for permanently sealing joints in tongue and groove concrete sewer pipe, must adhere tightly to the pipe surface, and form a tight flexible joint. The gaskets or sealants shall be installed as directed by the manufacturer of the pipe.

(e) Flared end sections, bends and tees shall comply with the requirements of ASTM C76 and shall be the same class and shall have the same joint design as the pipe described above.

(f) Visual inspections of all materials shall be made at the job site, and pipe will be rejected on account of any deficiencies covered by ASTM Specification Designation C76 or on account of the following:

(i) Porous spots, inside or outside, having a greater area than 10 square inches and a depth of more than 1/4 inch;

(ii) Patched or repair of porous spots or other defects that are not approved by the Director; or

(iii) Exposure of reinforcement that indicates the reinforcement has been replaced.

(C) Execution

(1) Laying Pipe

(a) All materials shall be carefully lowered into the trench piece-by-piece by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage. Under no circumstances shall materials be dropped or dumped into the trench. All pipe shall be inspected for defects prior to installation. Any defective, damaged or unsound pipe shall be rejected.

(b) All foreign matter or dirt shall be removed from the inside of the pipe and fittings before the pipe is lowered into its position in the trench. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. If the pipe-laying crew is unable to place the pipe into the trench without getting foreign matter or dirt into it, the Director may require that, before lowering the pipe into the trench, a heavy, tightly woven canvas bag of suitable size be placed over each end and left there until the connection is to be made to the adjacent pipes.

(c) An approved snug-fitting stopper or plug shall be installed in each pipe immediately after it is laid and prior to any further excavating, or backfilling. All openings along the line of the main shall be securely closed as directed and, in the suspension of work at any time, stoppers shall be placed to prevent dirt or other substances from entering the main. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

(d) Pipes shall be laid to a true line and at uniform rates of grade between manholes as shown on the approved construction plans. Fine grading to the bottom of the barrel shall proceed ahead of the pipe laying. The grade shall be accurately established for each joint by laser beam, or other means approved in writing by the Director. The laser beam shall be checked with a level each time it is moved and each day before construction proceeds, and thereafter as required to assure that it is set at the correct alignment. If any errors of grade are observed, pipe laying shall stop until the grade is corrected.

(e) Pipe laying shall proceed upgrade with the spigot ends pointed in the direction of flow. No pipe shall be laid in water or when the trench conditions are unsuitable for such work. The contractor shall make all connections of pipe to the manholes that have previously been constructed. When connecting to existing sewers, the contractor shall take every precaution necessary to prevent dirt or debris from entering the existing lines.

(f) Bedding shall be placed under and on both sides of the pipe as each length of sewer pipe is installed.

(2) **Joining Pipe**

(a) Use a method of joining pipe sections that ensures that ends are fully entered and inner surfaces are flush and even. The equipment used to force the joints together must be adequate enough to overcome the gasket pressure involved.

(b) Just prior to joining the pipes, the ends of the pipe shall be thoroughly cleaned with a wire brush to remove all foreign substances that may have adhered to the pipe surface. All dust and dirt shall be removed with a clean rag. A lubricating solution that is not injurious to the gasket or concrete, such as flax soap or water glass, shall be liberally applied to the gasket groove and to the entire surface of the bell ring. Following this operation, a thin film of lubricant shall be applied to the gasket that shall then be snapped into place in the groove, after which a small diameter smooth steel rod shall be inserted between the gasket and groove and run completely around the gasket to equalize the gasket tension.

(c) In the event that any foreign matter becomes imbedded in the lubricant, or the lubricant becomes contaminated by water or other substances before the joint is started, the area affected shall be re-cleaned and new lubricant shall be applied.

(d) The pipe being jointed shall be carefully moved into position, be line and grade checked, and as the spigot end is started into the bell of the section previously laid, the gasket position shall be checked to ensure uniform entry into the bell at all points.

(3) **Testing and Flushing Pipe**

(a) Prior to acceptance of each section of storm sewer line, the contractor shall jet clean all sewers up through 18 inches in diameter. Larger storm sewers shall be cleaned by other appropriate methods approved by the Director. All dirt and debris shall be prevented from entering the existing storm sewer system by means of watertight plugs or other suitable methods.

(b) If the Director finds it necessary to clean the mains immediately after construction by rodding, jetting, or both, the Director shall assess the contractor for the cleaning at a set per foot charge with a minimum dollar amount.

(c) The Director will televise all mains as part of public inspection, and will bill the contractor for the televising at a set per foot charge with a minimum dollar amount. Any defects found during the televising shall be repaired by the contractor, in a manner approved by the Director.

(d) Any visible infiltration, that the Director finds to be the result of poor installation of the specified materials, shall be repaired by the contractor in a manner approved by the Director before the work will be accepted.

(e) Before acceptance of the work, the Director will survey the manhole invert and surface elevations. Any inverts or surface elevations not meeting the approved design in the construction plans shall not be approved and shall be redone to the satisfaction of the Director.

(f) Upon completion of construction, the Director will carefully inspect all sewers and appurtenances. Any unsatisfactory work shall be removed and replaced by the contractor in a proper manner. The invert of sewer and manholes shall be left smooth, clean, and free from any obstructions throughout the entire line. Manhole rings and covers must be raised to finished grade before final acceptance of the sewer.

(g) For sanitary sewers, testing shall be as specified in Section 9.16, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

9.15 Manholes and Inlets

(A) General

(1) **Scope:** This section describes the furnishing and installation of precast concrete manholes, storm sewer inlets and appurtenances.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **General**

(a) Manholes shall be constructed of precast concrete riser sections, in accordance with Drawing No. 6.01, "Standard Sewer Manhole," in Chapter 11, "Technical Drawings," of these Standards. The concrete sections shall conform to ASTM C478. The top section required for change of diameter shall be concentric cone or flat slab. Invert channel shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. The minimum internal diameter of the manhole barrel shall be in Table 9-9, "Required Manhole Diameters," for all manhole installations:

Table 9-9: Required Manhole Diameters

Pipe Size (Diameter)	Inner Manhole Section Diameter
18 Inches (and Smaller)	4 Feet

Pipe Size (Diameter)	Inner Manhole Section Diameter
21 - 36 Inches	5 Feet
42 - 48 Inches	6 Feet
54 Inches (and Larger)	Special Detail

(b) The minimum internal diameter of the manhole barrel may also be determined by the number and size of pipes junctioning at a manhole. In such cases, the Director may modify the minimum internal diameter of the manhole barrel as required.

(c) To bring the manhole cover to the correct elevation, the adjustment section of each manhole shall be constructed of brick that is sound and true in shape and size and shall be Grade S-W from clay or shale. Precast concrete grade adjustment rings may be substituted for the brick. These rings shall be not less than 6 inches wide and furnished in heights to allow for 1 inch adjustment. Total adjustment height, with grade rings or bricks, shall not exceed 12 inches.

(2) **Joints:** Precast manhole and inlet joints shall be made watertight with RUB'R-NEK, Kent Seal No. 2, or LO-MOD GEL material, or approved equivalent. The diameter of gasket shall be as recommended by the manufacturer.

(3) **Frame and Cover:** Manhole frames and covers shall be of heavy duty traffic lids, Colorado Springs pattern, round base, 22-1/8 inch opening lids 1 inch thick, non-locking type with frame and cover weighing approximately 327 pounds. The cover and frame seat shall be machine finished to prevent any rocking of the cover in its associated frame. The cover shall have the word "SEWER" for sanitary sewer manholes, or "STORM SEWER" for storm sewer manholes clearly cast on the surface. Covers for other utility manholes shall also be marked with the appropriate utility designation. Frames and covers shall be CASTINGS, INC. MH 310 COVER B, or approved equivalent.

(4) **Manhole Steps:** Manhole steps shall be built into and thoroughly anchored to the manhole walls at time of fabrication and shall be positioned as shown on the approved construction plans, and in accordance with the technical drawings in Chapter 11. The material for extruded aluminum steps shall conform to Federal Specifications QQ-A-200/8 for aluminum alloy 6061 T6510 or T6511. The material for cast aluminum steps shall conform to ASTM B26 for aluminum alloy 535.0-F and be equal to ALCOA No. 12653B. Aluminum steps shall have plastic inserts or be coated with bituminous paint to protect against corrosion wherever they come into contact with cement. Copolymer polypropylene-coated steel steps Model PS-2-PF, as manufactured by M.A. Industries, are also acceptable.

(5) **Grout:** Grout shall be "non-shrink" type with aluminum filings; grout with iron filings is not acceptable. Grout shall be "Five Star Grout," "Embeco Grout" or equivalent.

(6) **Concrete:** Concrete for cast-in-place manhole bases shall have a 28-day compressive strength of not less than 3,000 psi. The maximum water content shall be 0.5 pounds of water per pound of cement. Entrained and entrapped air shall be between 4 and 9 percent. All reinforcement shall be standard deformed reinforcement conforming to the requirements set forth in ASTM, A615, Grade 60.

(7) **Inlets:** Inlets shall be constructed of reinforced concrete and shall conform to the dimensions and specifications as set forth for Type "R" Curb Inlets in Chapter 11, "Technical Drawings," of these Standards, and CDOT's M & S Standards. Inlet steps shall be built into and thoroughly anchored to the walls at the time of inlet construction. These

steps shall conform to the requirements for manhole steps, and shall be positioned as shown on the technical drawings.

(C) Execution

(1) **Construction of Manholes**

(a) Concrete bases shall be poured on undisturbed ground. Pipe sections shall be flush on the inside of the structural wall (except as noted below) and project outside sufficiently for proper connection to the next pipe section. All pipelines into a manhole shall have a joint located no more than 12 inches from the exterior wall. Where incoming pipes enter a storm drain manhole at an elevation 3 feet or greater above the base, the incoming pipe shall project 2 inches inside the manhole. All annular spaces around the pipe opening shall be grouted.

(b) For all precast manhole bases, the ground surface below precast concrete bases shall be excavated 6 inches below the elevation of the bottom of the base and backfilled with bedding material, meeting the requirements of Subsection 9.02(B) of these Standards. The bedding material shall be carefully leveled and smoothed as to give uniform support to the precast base over its entire area.

(c) The invert channels of manholes shall be constructed in accordance with the Drawing No. 6.03, "Manhole Invert," in Chapter 11, "Technical Drawings," of these Standards. They shall be smooth and semicircular in shape, conforming to the inside of the incoming and outgoing sewer pipelines. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Where differences of 24 inches or less in invert elevations are called for, sloped flow channels shall be formed so the water does not undergo a vertical drop. A drop manhole shall be installed where the specified distance in the manhole inverts exceeds 24 inches. The inlet channels may be formed directly in the concrete of the manhole base. The floor of the manhole outside of the channel shall be smooth and shall slope towards the channel not less than 1 inch per foot nor more than 2 inches per foot. The manhole covers shall be set with a final elevation of 1/4 inch below the finished grade in roadways and 1 to 2 inches above grade outside of roadways. When a manhole is located in the pavement area, it shall not be constructed to final grade until the pavement has been completed, unless directed otherwise by the Director.

(d) Install joint material per manufacturer's instructions so that no voids are present. Grout all joints inside and outside after manhole assembly is completed.

(e) Gaskets for connecting PVC pipe to manhole sections shall be specifically manufactured for that purpose. The gasket shall provide for at least five bearing points on the pipe surface. The interior circumference of the gasket shall be approximately 5 percent less than the exterior circumference of the pipe. The gasket shall be as manufactured by Hamilton Kent Mfg. Co. of Kent, Ohio, or approved equivalent. All annular spaces around pipe openings must be grouted.

(f) Stubs shall be provided at manholes when indicated on the construction plans. Such stubs shall be sealed with a removable plug. Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation.

(2) **Adjusting Manhole Tops:** When grade adjustment of an existing structure is specified, remove frames and covers and reconstruct as required. Reset cleaned frames at the indicated elevation. Prior to final acceptance, clean structures of accumulations of silt, debris, or foreign matter.

(3) **Testing Manholes:** Refer to Section 9.16, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

9.16 Testing of Gravity Sewer Pipelines and Manholes

(A) General

This section describes the testing of gravity sewer pipelines and manholes including sanitary sewers and storm drains.

(B) Materials

The contractor shall provide all equipment and material specifically designed for the testing specified in this section.

(C) Execution

(1) **Notification and Witness:** The contractor shall notify the Director of all tests at least 48 hours prior to testing so that the Director can witness the tests.

(2) **When to Test:** The pipe shall be tested for leakage after the pipe installation and the trench has been partially backfilled, except at the joints, or backfilled as permitted by the Director. Where any section is provided with concrete thrust blocks, the pressure test shall not be made until at least 2 days have elapsed after the concrete was installed.

(3) **Testing Procedures**

(a) **General:** The contractor shall flush the pipelines, as the work progresses, by means that are in accordance with good construction practice, to insure that earth, sand, rocks, or other foreign materials are removed from the interior of the pipeline. Care shall be taken to insure that foreign material is not transported downstream into the existing system.

(b) **Alignment and Grade:** Gravity sewer pipelines will be checked by the Director to determine whether any displacement of the pipe has occurred after the trench has been bedded to an elevation 6 inches above the pipe and tamped as specified. The test will be as follows:

(i) A light will be flashed between manholes, or if the manholes have not as yet been constructed, between the locations of the manholes, by means of a flashlight or by reflecting sunlight with a mirror. If the illuminated interior of the pipeline shows poor alignment, displaced pipe, earth, or other debris in the pipe, or any other kinds of defects, as determined by the Director, these deficiencies shall be corrected at the contractor's expense. The test will be repeated after completion of backfilling.

(ii) For sewers on curved alignment, a heavy rubber ball shall be passed through the pipe between manholes, or the location of manholes if not constructed, after the pipe has been laid and backfilled. The outside

diameter of the ball shall be the same as the inside diameter of the sewer pipe. The ball shall be placed at the upper manhole of the sewer to be cleaned. A head of water shall be placed against the ball to force the ball through the sewer and debris flushed from the line shall be collected at the lower manhole, or its location. The ball shall be secured by a line to control the rate at which the ball is allowed to pass through the sewer.

(4) **Air Tests**

(a) Air testing of sanitary sewer pipes shall be done on all sections of pipe between manholes. The pipe shall be cleaned and may be wetted before air testing. The section of pipeline being tested shall be plugged at each manhole with pneumatic balls.

(b) Low-pressure air shall be introduced into the plugged line until an internal pressure of 4 psig greater than the average backpressure of any ground water pressure that may submerge the pipe would cause. At least 2 minutes shall pass to allow air temperature to stabilize before the test time is started.

(c) No pipeline installation will be accepted if the pressure drops 0.5 psig or more during the time and for the length of pipe shown in Table 9-10, "Specifications for Air Testing of Sanitary Sewer Pipes," of these Standards:

(d) If the pipeline installation fails the air test, repairs shall be made and the pipe shall be retested until it passes the air test.

(5) **Deflection**

(a) All PVC non-pressure pipes shall be tested for vertical deflection after placement and compaction of backfill. The maximum deflection allowed is 5 percent.

(b) Method of testing shall be by deflectometer of the rigid GO/NO-GO type device. Any and all pipe with vertical defection greater than the allowable shall be excavated, and removed from the pipeline, replaced, backfilled and compacted as specified, and retested at the contractor's expense.

Table 9-10: Specifications for Air Testing of Sanitary Sewer Pipes

Pipe Diameter (Inches)	Minimum Test Time for Pipe Lengths up to Lengths in Column 3 (min:sec)	Maximum Pipe Length for Minimum Time Testing in Column 2 (Feet)	Minimum Test Time for Pipe Lengths Greater than Column 3 (Seconds)
4	1:53	597	0.190 x Pipe Length (Feet)
6	2:50	398	0.427 x Pipe Length (Feet)
8	3:47	298	0.760 x Pipe Length (Feet)
10	4:43	239	1.187 x Pipe Length (Feet)
12	5:40	199	1.709 x Pipe Length (Feet)
15	7:05	159	2.671 x Pipe Length (Feet)

(6) **Television:** All PVC non-pressure pipes shall be televised. Any defects found during televising shall be repaired.

(7) **Exfiltration Test**

(a) Sanitary sewer pipes and manholes may be leak tested using the exfiltration test when the air or vacuum testing is impractical.

(b) The test section shall be bulkheaded and the pipe subjected to a hydrostatic pressure produced by a head of water at a depth of 2 feet above the crown of the sewer at the upper manhole under the test. In areas where ground water exists, this head of water shall be 2 feet above the existing water table.

(c) The head of water shall be maintained for a period of 1 hour during which it is presumed that full absorption of the pipe body has taken place, and thereafter for further period of 1 hour for the actual test of leakage. During this 1 hour test period, the measured maximum allowable rate of exfiltration for any section of sewer, including service stubs, shall not be greater than 200 gallons per inch of pipe diameter per mile of pipe per day. To determine the allowable leakage in manholes, the manholes shall be treated as pipe of equivalent diameter.

(d) If the pipeline installation fails the exfiltration test, repairs shall be made and the pipe shall be retested until it passes the exfiltration test. All repairs or pipe replacements required to meet the leakage specifications must be acceptable to the Director.

(e) The contractor shall furnish all material and labor required to perform the test, and shall assist the Director in making measurements required by the test. The contractor shall be responsible for all costs associated with making the leakage tests or corrective work necessary to reduce leakage below the maximum allowed by these Standards.

(D) Sanitary Sewer Manholes

(1) **General**

(a) During the construction of the manholes, the contractor shall, in accordance with good construction practice, insure that no earth, sand, rocks or other foreign

material exists on the joint surfaces during assembly of the sections. The Director shall check each manhole to determine whether the manhole fulfills the requirements of the construction plans and these Standards.

(b) The Director shall visually check each manhole, both exterior and interior, for flaws, cracks, holes, or other inadequacies that might affect the operation or watertight integrity of the manhole. Should any inadequacies be found, any repairs deemed necessary by the Director shall be made by the contractor.

(c) Exfiltration tests as specified above shall be performed on all sanitary sewer manholes.

(2) **Vacuum Testing:** When required by the Director, sanitary sewer manholes shall be vacuum tested with the following procedure:

(a) Each manhole shall be tested immediately after assembly and prior to backfilling.

(b) All lift holes shall be plugged with an approved non-shrink grout.

(c) No grout will be placed in the horizontal joints before testing.

(d) All pipes entering the manhole shall be plugged, taking care to securely brace the plugs from being drawn into the manhole.

(e) The test head shall be placed at the inside of the top of the cone section and the seal inflated in accordance with the manufacturer's recommendation.

(f) A vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum drop to 9 inches. The manhole shall pass if the time is greater than 60 seconds for one 48 inch diameter manhole, 75 seconds for 60 inches, and 90 seconds for 72 inches.

(g) If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn. Retesting shall proceed until a satisfactory test is obtained.

9.17 Corrugated Metal Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of corrugated metal pipe and appurtenances for drainage culverts in the pipe diameter size range of 12 to 54 inches.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Corrugated Metal Pipe**

(a) Pipe shall be fabricated from zinc-coated (galvanized) iron or steel sheets conforming to AASHTO M-218 except as modified herein. The diameter or span by rise dimensions indicated on the drawings shall mean the nominal inside dimensions of the conduit. The widths of the laps and depths or corrugations shall be as specified in AASHTO M-36. The pipe shall have the following minimum gauge

(specified thickness) for the sizes shown in Table 9-11, "Corrugated Base Metal Specifications," of these Standards:

Table 9-11: Corrugated Base Metal Specifications

Diameter (Inches)	Gauge Number	Specified Galvanized Thickness (Inches)	Specified Galvanized Thickness (Inches)
21 and Smaller	16	0.064	0.0598
24	14	0.079	0.0747
30 - 54	12	0.109	0.1046

(2) **Dimpled Coupling Bands:** The dimpled coupling bands shall be the same thickness as that used for the pipe and shall be at least 12 inches wide. The dimples shall conform substantially to the shape and depth of pipe corrugations and shall be in circumferential rows. Each row shall contain dimples so spaced as to effectively engage all corrugations of the pipe ends. All bands shall have at least two zinc coated bolts per connection, conforming to ASTM A 307, grade A, electroplated in accordance with ASTM A 164, Type RS, not less than ½inch in diameter. The bands shall have end connection angles, conforming to ASTM A 36, zinc-coated in accordance to ASTM A 153, not less than 2 inches by 2 inches by 3/16 inch by 11 inches, adequately fastened to the band.

(3) **Fittings (Including Flared End Sections) and Specials:** Fittings and specials shall be of the same material, coating, and wall thickness, including the same structural qualities, as the adjoining pipe. Steel flared end sections shall be furnished complete with field-bolted toe plates.

(4) **Repair of Damaged Spelter Coatings:** Units such as tees, angles or bends on which the spelter coating has been burned by flame cutting and gas or arc welding, or otherwise damaged in fabrication or shipping, shall be wire-brushed and painted with two coats of Haltz-Rust HR-54-53 or equal conforming to Federal Specification and Standards, TT-P-641, or as otherwise approved by the Director. Culverts, pipes, fittings, specials, etc., on which the spelter coating has been bruised or broken either in the shop or in shipping, or that shows defective workmanship, will be rejected.

(C) Execution

Installation of corrugated steel pipe is considered to be a flexible conduit and, therefore, special care must be taken during the bedding and backfilling operations. Installation and backfilling operations shall be in accordance with the recommended practices set forth in the "Handbook of Steel Drainage and Highway Construction Projects," published by the American Iron and Steel Institute.

(1) **Bedding**

(a) All pipe shall be bedded with an approved granular bedding material. The pipe shall be bedded true to line and grade with uniform and continuous support from a firm base. Blocking shall not be used to bring the pipe to grade.

(b) The bedding material shall be placed evenly on both sides of the pipe to a point 12 inches above the top of the pipe. Special care shall be taken to insure that all voids are filled beneath the pipe haunch and that the bedding material is properly placed

and compacted to provide lateral restraint. The trench sidewall shall be adequately braced, shored or sheeted as necessary to stabilize the trench walls. The trench shall not be any wider than necessary for proper installation, and pipe jointing. The bedding material shall be placed under haunches and around the pipe alternately in 6-inch layers on both sides of the pipe to permit thorough consolidation of the bedding material. This material is placed alternately to keep it at the same elevation on both sides of the pipe at all times.

(2) **Backfilling:** After the pipe has been properly installed and bedded, the remaining trench excavation shall be restored as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981. Pipe installed outside of public rights-of-way where no pavement is impacted may be backfilled in the following manner. The backfill shall be placed in 8 inch loose lifts and compacted to 90 percent Standard Proctor density (AASHTO T-180) with mechanical hand tampers, for the first 2 feet. At least 4 feet of cover over the top of pipe shall be provided before the use of wheel-mounted mechanical tampers (free drop hammer), hydraulic tampers, (Hydraulic ram hammers) or other heavy tamping equipment will be permitted. Puddling or jetting will not be allowed.

(3) **Removal of Trench Protection:** Extreme care shall be taken in the removal of cribbing, shoring, sheeting, etc., so as not to disturb previously constructed foundation, bedding and initial backfill. If it was necessary to place or drive sheeting or other trench protection below the top of the pipe, the sheeting, shoring, etc., shall be cut off at a point 1 foot above the pipe and the remaining material shall be left in place. Removal of this portion could seriously jeopardize the side support necessary for "flexible conduits" and create excessive lateral soils pressures and pipe deflections.

(4) **Protection of Conduit During Construction:** Maximum supporting strength in flexible conduits does not develop until the fill consolidates. Therefore, excessive concentrated loads or heavy equipment on top of or along side if the pipe shall be avoided.

9.18 Cured-in-Place Pipe (CIPP)

(A) General

(1) **Scope:** This section describes the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube that is inserted into the original conduit by use of a hydrostatic head.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Resin-Impregnated Tube**

(a) The tube shall meet the requirements of ASTM F1216 and shall have a uniform thickness that, when compressed at installation pressures, will equal the specified nominal tube thickness, with a -5 percent manufacturing tolerance. The tube shall be fabricated to a size that when installed will tightly fit the internal circumference and length of the original pipe. Allowance should be made for circumferential stretching during insertion. The minimum length shall be that deemed necessary by the contractor to effectively span the distance between respective access points

unless otherwise specified. The contractor shall verify the lengths and diameters in the field before fabricating the tube. Individual insertion runs can be made over one or more manhole sections as determined in the field by the contractor. The maximum allowed insertion run is 1,200 feet. Intermediate manholes will be reopened as directed by the Director.

(b) The outside layer of the tube (before insertion) shall be translucent plastic coated with a flexible material that clearly allows inspection of the resin impregnation (wet-out) procedure. The translucent plastic coating on the tube will allow visual proof that the resin has wet-out the entire tube and that there are no dry areas. A vacuum shall be used to ensure the resin fills all dry areas. The plastic coating shall not be subject to delamination after curing of the CIPP.

(c) The tube shall be homogenous across the entire wall thickness containing no intermediate or encapsulated elastomeric layers. No materials will be allowed in the tube that is subject to delamination of the cured CIPP.

(d) The wall color of the interior pipe surface of the CIPP after installation shall be white or light brown so that a clear detail examination with closed circuit television inspection equipment can be made.

(2) **Resin:** The resin system shall meet the requirements of ASTM F1216.

(3) **Structural Requirements**

(a) The CIPP wall thickness will be measured in accordance with the applicable sections of ASTM Test Method D2122. Sufficient readings, at least eight, will be made to ensure that the minimum thickness has been determined. A cylindrical anvil tubing micrometer accurate to +0.02mm (+0.001 in) will be used. The minimum wall thickness at any cross section shall meet or exceed those shown on the proposal forms and the approved plans, with the allowable minus five (-5) percent tolerance. The wall thickness tests will be performed by a Certified Independent Laboratory, approved by the Director. All costs, for testing, shall be borne by the contractor.

(b) The layers of the CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe or point of a knife blade so that the layers separate cleanly of the probe or knife blade moves freely between the layers, nor shall separation of any layers occur during testing performed under the requirements of this specification.

(c) The cured pipe material (CIPP) shall conform to the minimum structural standards, as follows:

(i)	Flexural Stress (ASTM D-790)	4,500 psi
(ii)	Modulus of Elasticity (ASTM D-790)	250,000 psi

(C) Execution

(1) **Cleaning**

(a) The contractor shall be required to remove all internal debris from the sewer line by use of water jet equipment prior to inserting the CIPP tube. The cleaning operation

shall remove any and all debris so that each joint of pipe can be thoroughly inspected and successfully reconstructed.

(b) All sludge, dirt, sand, rocks, grease and other solid or semi-solid material resulting from the cleaning operation shall be removed at the downstream manhole of the section being cleaned. Passing material from one manhole to another will not be permitted.

(c) All such debris resulting from the cleaning operations shall be removed from the site and disposed of in the proper manner. The contractor shall bear all costs associated with testing of debris and proper dumping. Dumping of the debris shall be in accordance with all local, state, and federal regulations.

(d) All debris shall be removed from the downstream manhole and the site no less often than at the end of each workday. The contractor shall leave no debris unattended at the site. Under no circumstances will the contractor be allowed to accumulate debris beyond the stated time. In the event the contractor has not removed the debris generated by the cleaning operation, the contractor will not be allowed to proceed with the work until the debris is properly removed.

(e) During all sewer cleaning operations, satisfactory precautions shall be taken to protect the sewer lines from damage that might occur by improper use of cleaning equipment. Precautions shall be taken to ensure that the cleaning operation will not cause any damage or flooding to public or private property being served by the section of sewer line being cleaned. The contractor shall bear all costs associated with any flooding or damage to basements or structures.

(2) **Bypassing Sewage:** The contractor shall provide for the flow of sewage around the section(s) of pipe designated for reconstruction. The bypass shall be made by plugging the sewer line at an existing upstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow. Bypassing includes any main lines and service lines, street gutters or open excavations. Any spills that occur must be immediately cleaned and the affected area disinfected.

(3) **Inspection of Pipelines:** Inspections of pipelines shall be performed by trained personnel experienced in locating breaks, obstacles and service connections by closed circuit television. The inspection of pipelines is also to determine active service connections and the addresses that they serve. The interior of the pipe shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the CIPP into the pipeline and it shall be noted so these conditions can be corrected. A videotape and suitable log shall be submitted to the Director, and shall be kept for later reference.

(4) **Line Obstructions:** It shall be the responsibility of the contractor to clear the line of obstructions such as solids and roots that will prevent the insertion of the CIPP. If pre-installation inspection reveals an obstruction such as a protruding service connection, dropped joint, or a collapse that will prevent the inversion process, and it cannot be removed by conventional sewer cleaning equipment, then the contractor shall repair the excavation to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the Director prior to the commencement of the work.

(5) **CIPP Installation**

(a) CIPP installation shall be in accordance with ASTM F1216, Section 7, with the additional following requirements. The resin shall be cured by circulating hot water

within the tube. After curing, the finished pipe (CIPP) shall be continuous and tight fitting.

(b) The contractor, and the Director, shall designate a location where the tube will be impregnated with resin prior to installation, in order that an inspection can be made to determine proper materials and procedures. A resin and catalyst system compatible with the requirements of this method shall be used.

(c) The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat supply. Another such gauge shall be placed at the remote manhole to determine the temperature at that location during the cure. If air pressure and steam are used with styrene based resins, the compressed atmosphere shall be monitored with a safety gas detector to ensure that it does not reach the explosive limit.

(d) The finished CIPP shall be continuous over the entire length of an insertion run between two manholes and be free, as commercially practicable, from visual defects such as foreign inclusions, dry spots, pinholes, and delamination. It shall also meet the leakage/pressure test requirements specified below (water tightness).

(e) Before the insertion process begins, the minimum pressure required to hold the tube tight against the existing conduit and the maximum allowable pressure so as not to damage the tube shall be provided by the tube manufacturer, and it will be the contractor's responsibility to obtain and submit this information to the Director. Once the insertion has started, the pressure shall be maintained between the minimum and maximum pressures until the operation has been completed. If air pressure is used for inversion, the equipment shall be fitted with a pressure gauge accurate to 0.01 psi. Should the pressure deviate from within the range of minimum and maximum pressures, the installed tube will be rejected and the contractor will remove and dispose of the tube, at their expense.

(f) Before the curing process begins, the pressure required to hold the flexible tube tight against the host pipe shall be provided by the tube manufacturer and submitted to the Director prior to any inversion process. Once the cure has started and dimpling for laterals is completed, the required pressure shall be maintained until the cure is complete. Should the pressure deviate more than 1 psi (2.3 feet of water) from the required pressure during the critical curing period, the tube will be rejected and the contractor will be responsible for its removal and disposal and replacement with new CIPP at, at their expense. A complete log of the pressures shall be maintained on site and shall be offered to the Director after each inversion.

(6) **Sealing at Manholes:** If the CIPP fails to make a tight seal against the original pipe at its termination point(s), the space between the pipes shall be sealed by filling with a resin mixture compatible with the cured-in-place pipe and as recommended by the manufacturer.

(7) **Service Connections**

(a) After the curing of the CIPP is completed, the contractor shall restore the existing active service connections and branch connections. It is the intent of these Standards that active service and branch connections be reopened without excavation, and in the case of non-man entry pipes, from the interior of the pipeline utilizing a remotely controlled cutting device, monitored by a closed circuit television camera, that re-establishes them to not less than 95 percent capacity, while conforming to the shape of the existing opening.

(b) The contractor shall verify the possession of at least two complete cutting devices in good working order before each insertion.

(c) If excavations for the purpose of re-opening connections are required, the contractor will be responsible for all costs and liability associated with such excavation and restoration work.

(d) No service connection shall remain out of service for more than 24 hours at a time unless the contractor has provided temporary facilities or other appropriate accommodations for the affected service.

(8) **Testing:** CIPP samples shall be prepared and tested in accordance with ASTM F1216, Section 8.1, using both methods 8.1.1 and 8.1.2. The test will be performed by a Certified Independent Laboratory, approved by the City. Tests results shall be submitted to the Director. Costs of the tests are considered to be incidental to the project.

(9) **Visual Inspection:** Visual inspection of the CIPP shall be in accordance with ASTM F1216, Section 8.4. The contractor shall furnish the Director with a color video tape that contains both the before and after conditions, and the restored service and branch connections with the addresses each connection serves.

(10) **Exfiltration Tests:** In the absence of ground water, and if so ordered by the Director, an exfiltration test shall be performed. Leakage testing of the CIPP shall be accomplished after curing when the CIPP has cooled down to ambient temperatures and while under a positive head and before any service connections are reinstated. This test is limited to pipe diameters of 36 inches or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 gallons per inch of internal pipe diameter per mile per day, providing all trapped air has been purged from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest point shall not exceed 10 feet of water or 4.3 psi and the water level inside the inversion standpipe shall be 2 feet higher than the top of the pipe being tested or 2 feet higher than the groundwater level, whichever is greater. The leakage quantity shall be gauged by the water level in the temporary standpipe placed in the upstream plug. The test shall be conducted for 1 hour. CIPP products where the pipe wall is cured while not in direct contact with the pressurizing fluid (e.g., a removable bladder) must be tested by an alternative method approved by the Director.

9.19 Telecommunication or Cable System Standards

The installation and construction of telecommunication or cable systems shall comply with the requirements as set forth in Chapter 11-6-5, “Boulder Cable Code,” B.R.C. 1981 and these Standards.

(A) General

(1) **Applicable National Standards:** All telecommunications and cable system construction shall conform to the requirements of the following standards:

(a) American National Standards Institute, Inc. (ANSI), Electronic Industries Association (EIA), and Telecommunications Institute of America (TIA) Standards: EIA/TIA Standards Proposal No. 2840-A, Proposed Revision of EIA/TIA-568 (if approved to be published as EIA/TIA-568-A), EIA/TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces, and TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.

(b) National Electrical Safety Code (NESC) C2-1993, published by the Institute of Electrical and Electronics Engineers (IEEE), Inc.

(c) National Electrical Code (NEC), published by the National Fire Protection Association (NFPA).

(d) Federal Communications Commission.

(e) Colorado Public Utilities Commission.

(f) Williams-Steiger Occupational Safety and Health Act (OSHA).

(2) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific underground and/or aerial cable routing and associated conduit, manhole and/or pole locations and specifications, shall be submitted to the Director office for review and approval.

(3) **Protection of Systems:** All systems shall be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Cable Protection**

(a) All buried telecommunications cable, shall be installed in conduit, PVC Schedule 40 or equivalent. Cable placement by means of direct plow-in will not be allowed within the City's rights-of-way.

(b) Major conduit duct banks (more than 4 conduits) and those comprising a portion of the City's telecommunications conduit backbone infrastructure shall be encased in concrete with a minimum strength of 2000 psi. When encased in concrete, conduit may be PVC Type EB, DB or equivalent. The concrete encasement shall have a minimum thickness of 4 inches around the entire conduit or duct bank.

(c) Multiple duct systems shall have spacers installed at intervals to allow the concrete mix encasement throughout the entire duct structure.

(d) Conduit placed by directional bore method will be allowed subject to approval by the Director.

(2) **Depth of Cover:** The minimum depth of cover over the conduit shall be 30 inches.

(3) **Trench Specifications - Roadway and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the City.

(b) Trenches shall be have a minimum width of 10 inches.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement and Sidewalks," B.R.C. 1981.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the City.

(b) Trenches shall be have a minimum width of 10 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to tress, shrubs or other landscaping or if construction is within 5 feet of a tree.

(5) **Alternative Installation Methods:** Boring methods may be allowed by the Director if the Director finds that these methods are advantageous to the City or if open trench methods are impractical.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between telecommunications or cable systems and other facilities shall be maintained as required by NESC Section 32, Underground Conduit Systems. Conduit systems for telecommunications and cable systems shall be separated from conduit systems for power supply systems by:

(i) 3 inches of concrete,

(ii) 4 inches of masonry, or

(iii) 12 inches of well-tamped earth,

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit in the trench.

(8) **Manholes**

(a) All cavities required for cable pulling purposes shall be constructed as load bearing manholes or handholes. Handholes shall not be placed in any traveled lane, road shoulders, sidewalk, multi-use path, or bike lane.

(b) Manholes or handholes shall be placed at maximum 1200 feet intervals. In no case shall conduit bend radius exceed 180 degrees between manholes. Manholes shall be installed at each street intersection at a minimum. Manholes shall be rectangular: 6 feet wide by 7 feet long by 4 feet deep; or circular 4 feet diameter with a nominal depth of 4 feet minimum.

(c) Manholes or handholes shall be installed flush or ¼” below the surrounding grade.

(C) Aboveground Facilities

(1) **Facility Protection:** All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(2) **Obstruction to Traffic Prohibited:** All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.

(3) **Clearances:** All aboveground telecommunications facility construction shall conform with the minimum clearances as specified in Section 23 of the NESC.

(a) Cables shall maintain the following minimum clearances between any adjacent or crossing power cables under all conditions of cable loading:

(i) Horizontal clearances shall be at least 5 feet from power cables at a potential of up to 129 kV, and at least 5 feet plus 0.4 inches per kV over 129 kV from power cables exceeding a potential of 129 kV.

(ii) Vertical clearances shall be at least 4 feet from power cables at a potential of up to 750 V, at least 6 feet from power cables at a potential of 750 V to 22 kV, at least 6 feet plus 0.4 inches per kV over 22 kV from power cables at a potential between 22 kV and 470 kV. Vertical clearances shall comply with NESC Rule 233C3 for minimum clearance from cables at a potential greater than 470 kV.

(b) Cables, poles, and stubs shall maintain the following minimum clearances from power conductors, power poles and other objects:

(i) Poles shall have a minimum clearance of 4 feet from fire hydrants, signal pedestals, and call boxes.

(ii) Cables shall have a minimum horizontal clearance from power poles in no wind conditions.

(iii) Poles and stubs shall have a minimum horizontal clearance of 5 feet in no wind condition from power wires up to 50 kV.

(c) Poles shall have a minimum separation of at least 2 feet from the street side of the curb to the nearest part of the pole and shall be located a sufficient distance from the street side of the curb to avoid contact with ordinary vehicles using the road.

(d) Poles shall have at least 12 feet horizontal clearance from the nearest rail to the nearest part of the pole.

(e) Cables shall have at least 2 feet vertical clearance from Police and Fire Alarm facilities.

(f) Cables shall have at least 3 feet clearance in all directions from signs, chimneys, tanks, and other installations.

(g) Cables shall maintain the following minimum vertical clearances as measured from the lowest point of the cable when crossing the following objects:

(i) Roads, Streets, and all areas subject to truck traffic: 18 feet.

(ii) Alleys, Driveways, and Parking Lots: 18 feet.

(iii) Railroad tracks: 28 feet.

(iv) Roofs, not accessible: 4 feet.

(v) Spaces and Ways, accessible to pedestrians only: 12 feet.

(vi) Roofs, accessible to vehicular traffic, but not trucks: 12 feet.

(h) Cables shall maintain a minimum vertical clearances of 16 feet as measured from the lowest point of the cable when running alongside but not overhanging roads, streets, or alleys.

(i) A minimum vertical clearance of 40 inches shall be maintained between telecommunications cables and power cables at the attachment points on joint use poles.

9.20 Electric Power Facility Standards

The following standards shall apply to all electric power related facilities constructed within the City's public rights-of-way or easements.

(A) General

(1) **Undergrounding Required:** All electric power facilities constructed in the City's public rights-of-way or easements shall be underground unless otherwise permitted by franchise or the Director.

(2) **National Standards:** All electric power facility construction shall conform to the requirements of the following standards:

(a) 1993 National Electrical Safety Code (NESC) C2-1993, published by the Institute of Electrical and Electronics Engineers (IEEE), Inc.

(b) National Electrical Code (NEC), published by the National Fire Protection Association (NFPA).

(c) Colorado Public Utilities Commission.

(d) Williams-Steiger Occupational Safety and Health Act (OSHA).

(3) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific underground and/or aerial cable routing and associated conduit, manhole and/or pole locations and specifications, shall be submitted to the Director for review and approval.

(4) **Protection of Facilities:** All facilities must be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Underground Cable Protection**

(a) All primary circuits (greater than 600 volts) located under concrete road surfaces, where circuit density is high, and in all arterial roads shall be installed in conduit, 4 inch minimum diameter, PVC Type EB, DB or equivalent. All conduit joints shall be solvent welded. The conduit shall be encased in concrete with a minimum strength of 2000 psi and have a minimum thickness of 4 inches around the entire conduit or duct bank.

(b) All secondary circuits (600 volts or less) supplying services larger than 800 amperes shall be installed in conduit, 2-inch minimum diameter, PVC Type EB, DB or equivalent. All conduit joints shall be solvent welded. The conduit shall be encased in concrete with a minimum strength of 2000 psi and have a minimum thickness of 4 inches around the entire conduit or duct bank.

(c) Multiple duct bank systems shall have spacers installed at intervals to allow the concrete mix encasement throughout the entire duct structure.

(2) **Depth of Cover**

(a) The minimum depth of cover over primary circuits (greater than 600 volts) shall be 42 inches.

(b) The minimum depth of cover over secondary circuits shall be 30 inches (600 volts or less).

(c) The minimum depth of cover over circuits for street lighting and signals shall be 18 inches.

(3) **Trench Specifications - Roadways and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall be have a minimum width of 10 inches.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement and Sidewalks," B.R.C. 1981.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall be have a minimum width of 10 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to trees, shrubs or other landscaping or if construction is within 5 feet of a tree.

(5) **Alternative Installation Methods:** Boring methods may be allowed by the Director if the Director finds that these methods are advantageous to the City or if open trench methods are impractical.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between electric power facilities and other facilities shall be maintained as required by the NESC section 32 Underground Conduit Systems.

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit or cable in the trench.

(8) **Manholes:** All cavities required for cable pulling purposes shall be constructed as load bearing manholes or handholes. Handholes shall not be placed in any traveled lane including road shoulders, sidewalks, multi-use paths, or bike lanes.

(C) Aboveground Facilities

(1) **General**

(a) All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(b) All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.

(2) **Clearances:** The minimum overhead transverse clearance shall conform to National Electrical Safety Code Standards, but shall not be less than 18 feet measured from the highest point of the road prism to the bottom of the cable.

9.21 Gas Distribution Facility Standards

The following standards shall apply to all gas distribution related facilities constructed within the City's public rights-of-way or easements.

(A) General

(1) **Undergrounding Required:** All gas distribution facilities constructed in the City's public rights-of-way or easements shall be underground unless otherwise permitted by franchise or the Director.

(2) **National Standards:** All gas distribution facility construction shall conform to the requirements of the following standards:

(a) Minimum Federal Safety Standards for Natural Gas Pipelines in the Code of Federal regulations 49 Part 192.

(b) Colorado Public Utilities Commission.

(c) Williams-Steiger Occupational Safety and Health Act (OSHA).

(3) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific gas distribution line and appurtenances locations and specifications, shall be submitted to the Director for review and approval.

(4) **Protection of Facilities:** All facilities must be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Materials**

(a) Steel or plastic material shall be used for the gas distribution pipe.

(b) All plastic pipe must be installed below ground level.

(2) **Depth of Cover**

(a) Depth of cover shall be measured from the final grade to the top of the pipe.

(b) Minimum depth of cover for shall be 36 inches for transmission lines and 30 inches for distribution lines.

(c) Minimum depth of cover for service lines shall be 24 inches.

(d) Transmission and distribution lines installed under streams and ditches must have minimum cover of 48 inches.

(3) **Trench Specifications - Roadways and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall have a minimum width of 10 inches.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, “Standards for Repairs and Restoration of Pavement and Sidewalks,” B.R.C. 1981.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall be have a minimum width of 10 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to tress, shrubs or other landscaping or if construction is within 5 feet of a tree.

(5) **Alternative Installation Methods:** Boring methods may be allowed by the Director if the Director finds that these methods are advantageous to the City or if open trench methods are impractical.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between gas distribution facilities and other facilities shall be 6 inches minimum.

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit in the trench.

(8) **Components**

(a) Transmission line valves shall be installed in boxes or be otherwise readily accessible.

(b) Transmission line pressure relief and pressure limiting devices shall be installed in underground vaults, unless aboveground installation is permitted by the Director.

(c) All service lines shall be equipped with shutoff valves.

(d) An electrically conductive tracer wire shall be installed with all plastic and non-conductive pipes.

(9) **Casing Pipe:** Gas pipe shall be installed in casings under all highways. Casing pipe shall be steel pipe with a wall thickness of 1/4 inch minimum extending at least 5 feet beyond the limits of any highway improvements.

(10) **Corrosion Protection**

(a) All pipes susceptible to corrosion shall be cathodically protected and have a protective coating.

(b) All corrosion susceptible pipes must also be electrically isolated from other metallic structures.

(C) Testing Requirements

All newly constructed pipes shall be tested prior to placing the line in service. No pipe shall be placed in service, or returned to service, with leaks or without adequate corrosion protection.

(1) **Pressure Testing:** All pipes shall be pressure tested for leakage as described in CFR 49 part 192. In order to establish the maximum allowable operating pressure (MAOP), pipes shall be tested at 1-1/2 times the MAOP.

(2) **Corrosion Control Testing:** Corrosion control devices shall be tested whenever the pipe is exposed for maintenance or repair. Additionally, all corrosion control devices must be tested at least once each calendar year.

(3) **Records Retention:** Records of the testing shall be maintained for the life of the pipe.

(D) Aboveground Facilities

(1) **Facility Protection:** All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(2) **Traffic Obstruction Prohibited:** All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.