Irrigation Water Conveyance (ft)

Reinforced Plastic Mortar Pipeline

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to underground reinforced plastic mortar pipelines 8 to 54 in. in diameter. Pipelines more than 54 in. in diameter shall be installed under special design and specification requirements.

The standard includes the design criteria for irrigation pipelines, the minimum installation requirements, and the specifications for the reinforced plastic mortar pipe to be used. It applies to pipelines with stands and vents open to the atmosphere and to pipelines not open to the atmosphere but provided with pressure-relief valves and air-and-vacuum valves.

Purpose

To prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions where practice applies

All pipelines shall be planned and located to serve an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies, quality, and rates of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Reinforced plastic mortar pipelines installed under this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

Design criteria

Working pressure. The pipeline shall be designed to meet all service requirements without a static or working pressure at any point greater than the maximum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include free board.

The minimum acceptable work pressure class shall be pipe having a rated operating head of 50 ft of water.

Friction losses. For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient , c, equal to 145.

Flow velocity. The design water velocity in the pipeline when operating at system capacity shall not exceed 5 ft/s. If this limit is exceeded, special considerations must be given to the flow conditions and measures to adequately protect the pipeline against surge.

Capacity. The design capacity of the pipeline shall be based on whichever of the following criteria requires the larger amount of water:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

Outlets. Appurtenances to deliver water from the pipe system to the land, to a ditch or reservoir, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch; (2) a point at least 6 in. above the field surface; (3) the design surface elevation in a reservoir; or (4) an individual sprinkler, lateral line, or other sprinkler line.

Check valves. A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow occurs.

Stands open to the atmosphere. Stands shall be used wherever water enters the pipeline system to avoid entrapment of air, to prevent surge pressures, to avoid collapse due to negative pressures, and to prevent pressure from exceeding the maximum allowable working pressure of the pipe. Open stands may be required at other locations in low-head systems to perform other functions. Stands shall be constructed of steel pipe or other approved materials and shall be supported on a base adequate to support the stand and to prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 ft of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design working head plus freeboard will exceed the allowable working pressure of the pipe.
2. The top of each stand shall extend at least 4 ft above the ground surface except for surface gravity inlets, which shall be equipped with trash racks and covers.
3. Downward water velocities in stands shall not exceed 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applies only to stands having vertical offset inlets and outlets.
4. If the water velocity in the inlet (from the pump or other water sources) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
5. The cross-sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet or outlet pipe, but the reduction shall not be such that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.
6. Vibration-control measures, such as special couplers or flexible pipe, shall be provided, as needed, to insure that vibration from pump discharge pipes is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet to the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s. Suitable provisions for cleaning sand traps shall be provided.

Gate stands shall be of sufficient dimensions to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valve stands shall be large enough to provide accessibility for maintenance and to dampen surge.

Stands closed to the atmosphere. If pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements detailed under "Stands Open to the Atmosphere" shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 ft above the top of the uppermost inlet or outlet pipe. To facilitate attracting the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point, or if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 ft/s if the entire flow were discharged through it. If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is "doglegged" below ground, the stand shall extend at least 1 ft above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the outletting pipeline) shall be:

1. Construct the dogleg section of the pump discharge pipe with the same nominal diameter as that of the pipeline.
2. Install the pressure-relief valve and the air-and-vacuum valve on top of the upper horizontal section of the dogleg.

Pressure-relief and air-and-vacuum valves shall be installed on stands with the nominal size pipe required to fit the valves threaded inlets.

Vents. Vents must be designed into systems open to the atmosphere to provide for the removal and entry of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 in. in diameter.

These cross-sectional requirements shall apply when an air-and-vacuum valve is used instead of a vent, but the reduced section shall be increased to the nominal size pipe required to fit the valve's threaded inlet. An acceptable alternative is to install this valve in the side of a service outlet riser, provided that the riser is properly located and adequately sized. If an air-and-vacuum valve and a pressure-relief valve are required at the location, the 10-ft/s velocity criterion given under "Stands" shall apply to the reduced section.

3. Be located at the downstream end of each lateral, at summits in the line, and at points where there are changes in grade in a downward direction of flow of more than 10 degrees.

Air-and-vacuum valves. An air-and-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling operations and allows air to reenter the line and prevents a vacuum from forming during emptying operations. This type of valve is sometimes called air-vacuum-release valve or air-vent-and-vacuum-relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

Air-and-vacuum valves may be used instead of vents at any or all the locations listed under "Vents." An air-and-vacuum valve also may be used in conjunction with a pressure-relief valve as an alternative to open pump stands. A pipeline is considered open to the atmosphere if at least one stand, vent, or service outlet is unclosed and located so that it can not be isolated from the system by line gates or valves.

On low-pressure pipelines not open to the atmosphere, air-and-vacuum valves shall be installed at all locations specified under "Vents," on all pump stands, and at inline control devices where there is a need for air removal and entry during filling and emptying operations.

Air-release and vacuum-release valve outlets shall be at least 1 in. in diameter when specified for lines 5 to 8 in. in diameter, at least 2-in. for lines 10 to 16 in. in diameter, at least 4-in. for lines 18 to 28 in. in diameter, at least 6-in. for lines 30 to 36 in. in diameter, and at least 8-in. for lines 38 to 48 in. in diameter.

For pipelines larger than 16 in. in diameter, 2-in. air-release valves may be used instead of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

Manufacturers of air-and-vacuum valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selection and acceptance of these valves.

Pressure-relief valves. Pressure-relief valves may be used on low-pressure pipelines as an alternative to stands open to the atmosphere.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures are likely to build up, a surge chamber or pressure-relief valve shall be installed close to the check valve on the side away from the pump.

Pressure-relief valves shall be no smaller than 1/4-in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 $lb/in.^2$ above the pressure rating of the pipe.

A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

The flow capacity of pressure-release valves shall be the pipeline design flow rate within a pipeline pressure no greater than 50 percent above the permissible working pressure for the pipe.

The pressure at which the valve starts to open shall be marked on pressure-relief valves. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

Drainage. Provisions shall be made for completely draining the pipeline if freezing temperatures are a hazard, the pipe manufacturer recommends it, or it is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets can drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping or other means.

Flushing. If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

Thrust control. Anchors or thrust blocks shall be provided on pipelines at abrupt changes in pipeline grade, changes in horizontal alinement, or reduction in pipe size to absorb any axial thrust of the pipeline. Thrust blocks may also be needed at the end of the pipeline and at inline control valves.

The pipe manufacturer's recommendations for thrust control shall be followed. In the absence of such recommendations, the following formula shall be used in designing thrust blocks:

$$A = \frac{98\, HD^2}{B} \sin \frac{a}{2}$$

Where:
A = Bearing area of thrust block required in ft^2
H = Maximum working pressure in ft
D = Inside diameter of pipe in ft
B = Allowable passive pressure of the soil in lb/ft^2
a = Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90-deflection angle of pipe bend.

If adequate soil tests are not available, the allowable bearing soil pressure may be estimated from table 1.

Maximum depth of cover. If the pipe is installed in a trench, the earth cover over the top of the pipe shall not exceed that given in table 2.

If the pipe is installed in an embankment, the external load shall not exceed a load equivalent to the height of earth cover over the top of the pipe given in table 3.

Table 1.—Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft.	4 ft.	5 ft.
	$lb/in.^2$			
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed ϕ = 40°)	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed ϕ = 35°)	800	1,200	1,650	2,100
Silt and clay mixture (assumed ϕ = 25°)	500	700	950	1,200
Soft clay and organic soils (assumed ϕ = 10°)	200	300	400	500

Table 2.—Maximum cover for pipes installed in trenches

Pipe diameter	Type 4 bedding	Type 7 bedding	Type 10 bedding
in.	ft.	ft.	ft.
8	35	35	35
10	23	35	35
12	18	35	35
14	15	35	35
15-16	13	35	35
18-20	12	35	35
21	11	35	35
24	11	28	35
27	10	25	35
30	10	24	35
33	10	23	35
36	10	22	35
39	10	21	35
42	9	20	35
45-54	9	19	35

Table 3.—Maximum cover for pipes installed in embankments

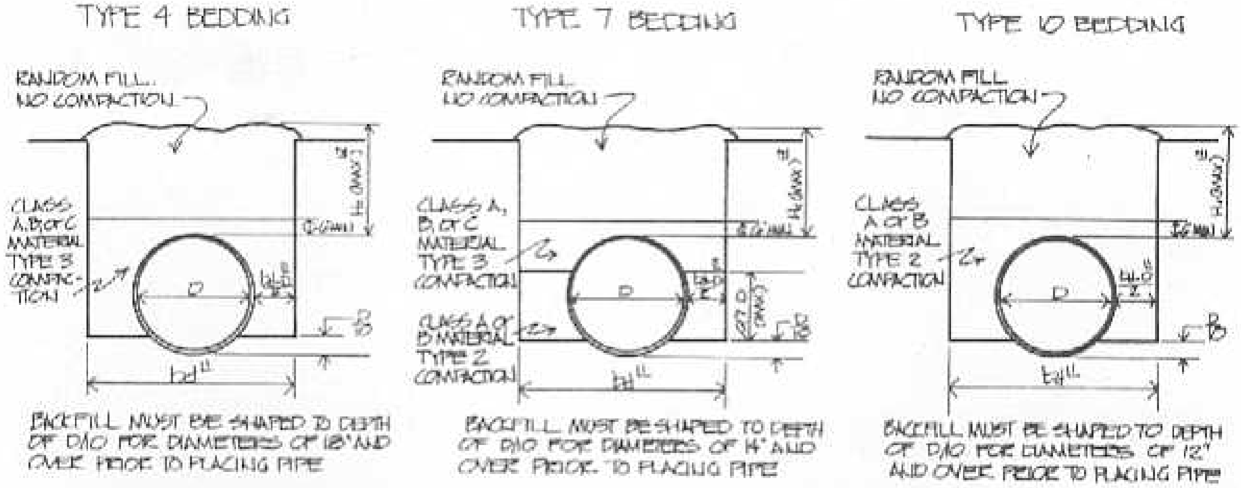
Pipe diameter	Type 4 bedding	Type 7 bedding	Type 10 bedding
in.	ft.	ft.	ft.
8	12	18	24
10	10	15	21
12	9	14	20
14	9	13	19
15-39	8	13	19
42-54	7	13	19

NOTE—Bedding conditions are given in figure 1 and in tables 6 and 7.

Materials. All materials described and required in this standard shall meet or exceed the minimum requirements indicated in "Specifications for Materials."

Plans and specifications

Plans and specifications for constructing reinforced plastic mortar irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.



Shape natural subgrade to fit the pipe to depth of D/10 by using a template or properly shaped excavating equipment. At the contractor's option, the subgrade may be excavated to 4 in. below the bottom of the pipe and backfilled with Class A material, Type 3 compaction. If the subgrade is rock, contains rocks larger than 1 in. in diameter, or is unstable, excavate to a depth of 6 in. below the bottom of the pipe, backfill with Class A material, Type 3 compaction, and shape backfill as instructed above. Pipe must be in contact with the subgrade at all locations along the pipe (no high or low spots except as needed for bell ends, rings, or fittings).

NOTES—Show appropriate value on drawings:

1. bd = D + 18 in. for compaction by water saturation; bd = D + 36 in. for mechanical compaction.
2. H_c = Height of fill used in design calculations.

Figure 1.—Bedding conditions for pipe.

Irrigation Water Conveyance

Reinforced Plastic Mortar Pipeline Specifications

Installation

Pipe shall be laid to the lines and grades as shown on the drawings and/or as staked in the field.

Minimum depth of cover. Pipe shall be installed at a sufficient depth below the ground surface to insure that the pipe is protected from damage imposed by traffic crossing, farming operations, freezing temperatures, or soil cracking. The minimum depth of cover shall be 24 in., but in soils susceptible to deep cracking, the cover shall be a minimum of 36 in. If the pipe must be placed at a lesser depth, adequate protection shall be provided by erecting fences or other surface barriers or by using suitable structural treatment to insure that excessive external loads are not transmitted to the pipe. The maximum depth of cover is given in tables 2 and 3 under "Design Criteria."

Trench construction. The pipe trench shall be straight enough so that the pipeline can be laid without unnecessary deflections at the joints. At any point below the top of the pipe, the trench shall be only wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be uniformly placed under the haunches and along the sides of the pipe. The maximum trench width shall not exceed 24 in. more than the pipe diameter.

The trench bottom shall be uniform so that the pipe lays on the bottom without bridging. Clods, rocks, and uneven spots that can damage the pipe or cause nonuniform support shall be removed.

If rocks, boulders, or any other material that can damage the pipe are encountered, the trench bottom shall be undercut a minimum of 4 in. below final grade and filled with bedding material consisting of sand or compacted fine-grained soils. Bell holes shall be excavated, as needed, to prevent the bells from coming into contact with the subgrade. Any water in the trench shall be drained away or otherwise removed, and pipelaying shall be delayed until a suitable firm base is obtained.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. The top width of the fill shall be no less than 10 ft and the side slopes no steeper than 6 horizontal to 1 vertical. The fill material shall be placed and compacted before excavating the trench. If extra protection is needed at vehicular crossings, encasement pipe or other approved methods may be used.

Provisions shall be made to insure safe working conditions if unstable soil, trench depth, or other conditions can impose a safety hazard to personnel working in the trench.

Placement. The pipe shall be lowered into the trench and placed into position in a manner that prevents damaging the joints or getting dirt inside the pipeline.

The pipe shall be uniformly and continuously supported over its entire length on firm stable material. Blocking or mounding shall not be used to bring the pipe to final grade.

Bell holes shall be excavated in the bedding material, as needed, to allow for unobstructed assembly of the joint and to permit the body of the pipe to be in contact with the bedding material throughout its length.

Joints and connections. All joints and connections shall be designed and constructed to withstand the design maximum working pressure for the pipeline without leakage and to leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

The connecting surfaces of the bell and spigot shall be thoroughly cleaned and dried before each joint is connected. The spigot recess, the rubber gasket, and the bell shall be lubricated with an approved gasket lubricant. After lubrication, the gasket shall be thoroughly stretched when it is placed in the spigot groove so that a uniform volume of rubber is distributed around the circumference of the pipe. The gasket shall not be twisted, rolled, cut, crimped, or otherwise damaged or forced out of position during closure of the joint. The position of the rubber gasket shall be checked after joint assembly, and if the gasket is not in the proper position, the pipe shall be withdrawn, the gasket checked to see that it is not cut or damaged, the pipe relaid, and the position of the gasket rechecked.

If the pipe is laid on tangent, each joint shall be fitted together so that the end of the spigot of one pipe is as close to being in contact with the shoulder of the bell of the adjacent pipe as practicable. On curves, the maximum deflection at any one joint shall not exceed 3 degrees for pipe sizes 30 in. and less in diameter and 1½ degrees for larger sizes.

All fittings, such as couplings, reducers, bends, tees, and crosses shall be installed according to the recommendations of the pipe manufacturer.

Fittings and appurtenances made of steel or other metals susceptible to corrosion shall be adequately protected by wrapping them with plastic tape or by applying a coating having high corrosion-preventative qualities. If plastic tape is used, all surfaces shall be thoroughly cleaned and then coated with a primer compatible with the tape before being wrapped.

Thrust blocks. Thrust blocks must be formed against solid unexcavated earth that is undamaged by mechanical equipment. They shall be constructed of concrete, and the space between the pipe and the trench wall shall be filled to the height of the outside diameter of the pipe or as specified by the manufacturer.

Testing. The pipeline shall be thoroughly and completely tested at the design pressure for pressure strength and leakage.

The line shall be slowly filled with water. Adequate provision shall be made for air release while filling. Care shall be taken to bleed all entrapped air. The pressure shall be slowly built up to the maximum design working pressure of the system. While this pressure is maintained, all exposed pipe, fittings, valves, hydrants, joints, appurtenances and covered parts of the line shall be examined for leaks. Any leaks shall be repaired and the system retested.

It shall be demonstrated by testing that the pipeline and all valves, vents, surge chambers, and other appurtenances will function properly at design capacity. At or below design capacity there shall be no objectionable flow conditions such as water hammer, continuing unsteady delivery of water, damage to the pipeline, or detrimental discharge from control valves, vents, or stands.

Backfill. The material shall be brought up to about the same level on both sides of the pipe and shall be compacted firmly around the pipe (table 4). If water packing is used, the pipeline shall be filled with water. The initial backfill shall be consolidated to achieve the density specified in table 5, or the material shall be placed in about 12-in. lifts or to the approximate spring line of the pipe, whichever is less. Saturation with internal vibration is an acceptable method of consolidating the primary backfill. The amount of water used for consolidation shall be controlled to insure no pooling. The wetted fill must be allowed to dry until firm before beginning the final backfill.

Final backfill material shall be free of large rocks or boulders and shall be added to the trench in a manner that will not damage the pipe. This material need not be compacted, but it shall be mounded over the top of the trench in a manner that will leave the fill at ground level after settlement. Rolling equipment shall not be used to consolidate the final backfill.

All special backfilling recommendations of the pipe manufacturer shall be followed.

Repairs. Individual pipe units may be repaired if defects result from imperfections in pipe manufacture or from accidental damage during handling. All repairs must be made by methods approved by the engineer. They must be sound and properly finished and cured. In addition, the repaired pipe must conform to the requirements of these specifications with respect to dimensions and tolerances. Hydrostatic tests may be required on any repaired pipe if deemed necessary by the purchaser (table 6).

Basis of acceptance. The acceptability of the pipeline shall be determined by inspections to insure compliance with all the provisions of this standard with respect to the design of the line, the pipe and pipe markings, the appurtenances, and the minimum installation requirements.

Certification and guarantee. If requested by the state conservation engineer, the manufacturer must certify that the pipe meets the requirements specified in this standard. The installing contractor shall certify that the installation complies with the requirements of this standard. He shall furnish a written guarantee that protects the owner against defective workmanship and materials for not less than 1 year. The certification shall identify the manufacturer and markings on the pipe used.

Table 4.—Backfill material classes

Material	Description
Class A	Sand, gravelly sand, or silty sand containing a maximum of 10 percent fines (material passing the No. 200 sieve and having 100 percent passing the 1-in. screen and at least 60 percent passing the No. 4 sieve). Fines must be nonplastic. (SW, SP, SW-SM, SP-SM)
Class B	Silty or clayey sand or gravelly sand having 10 to 50 percent fines, 1 in. maximum size, and at least 75 percent passing the No. 4 sieve. Maximum plasticity index (PI) of 7. (SM, SC)
Class C	Sandy or gravelly silt or clayey silt, sandy or gravelly clay or silty clay containing 50 to 100 percent fines and having 1 in. maximum size. Maximum plasticity index (PI) of 7. (ML, CL, CL-ML)
Random fill	Any soil, such as the material removed from an excavation. All cobblestones and rocks larger than 6 in. in diameter must be removed.

Table 5.—Compaction specifications

Type of compaction	Material	Performance	Method
1	Class A	80 percent of relative density by compacting material in 4-in. lifts (ASTM-D-2049).	Four passes on 4-in.-thick lifts with vibrating compactor weighing at least 200 lb and having an impact of at least 2,000 lb at 3,500 v/min.
1	Classes B and C	95 percent of maximum density obtained by ASTM-D-698. Material must be within 3 percent of optimum moisture and compacted in 4-in. lifts.	None.
2	Class A	70 percent of relative density when compacted in 4-in. lifts (ASTM-D-2049).	Two passes on 4-in.-thick lifts with vibrating compactor weighing at least 200 lb and having an impact of at least 2,000 lb at 3,500 v/min, or by complete saturation of the backfill material with water and internal vibration during saturation.
2	Class B	90 percent of maximum density obtained by ASTM-D-698. Material must be within 3 percent of optimum moisture and compacted in 4-in. lifts.	Two passes on 2-in.-thick lifts with vibrating compactor weighing at least 200 lb and having an impact of at least 2,000 lb at 3,500 v/min.
2	Class C	90 percent of maximum density obtained by ASTM-D-698. Material must be within 3 percent of optimum moisture and compacted in 4-in. lifts.	None.
3	Class A	None.	Carefully place material with a shovel in small lifts; make sure that all voids are filled with soil. Tamping with the shovel is done within 6 in. of the pipe.
3	Classes B and C	85 percent of maximum density obtained as recommended in ASTM-D-698. Material must be within 2 percent above to 5 percent below optimum moisture and compacted in 6-in., maximum, lifts.	None.

NOTES:
1. Pick either performance or method specification, not both.
2. Water saturation shall be used only if soils are well drained and if the water will drain into the subgrade.
3. Holes shall be excavated in the bedding for pipe bells to provide a clearance of 1 in.

Table 6.—Hydrostatic pressure test requirements

Class	Hydrostatic proof pressure: Water head (*ft.*)	Hydrostatic proof pressure: *lb/in.*^{2}
H50	100	43
H100	200	87
H150	300	130
H200	400	173
H250	500	217
H300	600	260
H350	700	303
H400	800	347
H450	900	390
H500	1,000	434

Materials

Pipe classes. Reinforced plastic mortar pipe shall be classified according to its rated operating head in feet of water. The classes are designated H50, H100, H150, H200, H250, H300, H350, H400, H450, and H500.

Lot definition. Material A lot, as used in this standard, means 100 lengths of pipe or fraction thereof of identical class and size manufactured in a single production run. A unit means a length of pipe or part of a length of pipe.

Pipe material. Reinforced plastic mortar pipe shall consist of an aggregate filler, a glass fiber reinforcement, and a resin binder.

The aggregate filler shall be a siliceous natural sand conforming to the requirements for concrete aggregate (ASTM-C-33), but the requirements for gradation shall not apply.

The reinforcement shall be manufactured from continuous rovings of borosilicate-type glass fibers with a polyester compatible finish.

The binder shall be a catalyzed isophthalic polyester resin with or without inorganic fillers.

Physical requirements. All pipe furnished under these specifications shall meet the test requirements for soundness, hoop tensile strength, and stiffness factor specified in ASTM-D-3517. Tests shall be performed by the manufacturer at his expense. Certified copies of the results of the tests shall be furnished to SCS upon request of the state conservation engineer.

Gaskets. Rubber gaskets, as used in these specifications, include natural rubber, synthetic rubber, or a blend of both. Rubber gaskets shall be extruded or molded and cured in such a manner that any cross section will be dense, homogeneous, and free from porosity, blisters, pitting, and other imperfections. They shall conform to the requirements specified in ASTM-D-1869 or in C-361, Section 5.9.

Joints. Pipe shall be furnished with bell and spigot ends for joining; a solid, uniform cross section rubber gasket shall be used as the sealing element. The gasket shall be contained in a groove and shall not support the weight of the pipe when two sections are joined. The joint assemblies shall be formed so that the pipe forms a continuous watertight conduit when the sections are drawn together. They shall provide for slight movements of any pipe in the pipeline due to expansion, contraction, settlement, or lateral displacement. The rubber gasket shall be the sole element of the joint depended upon to provide a watertight seal.

The volume of the gasket shall be less than 85 percent of the volume of the annular space in which the gasket is to be contained, with the engaged joint in concentric position. The gasket shall not be stretched more than 20 percent of its original length when full seated in the groove. The gasket's diameter shall be such that when the outer surface of the spigot and the inner surface of the bell come into contact at some point in their periphery, the deformation in the gasket shall not exceed 40 percent at the point of contact nor be less than 15 percent at any point. Stretched gasket diameters shall be calculated as being the original diameter divided by the square root of $(1 + X)$, where X is the percent of gasket stretch divided by 100. Determination of gasket deformation in an offcenter joint shall be based on the most unfavorable limits of the pipe manufacturer's tolerances.

Fittings. Fittings, such as tees, elbows, wyes, reducers, and adaptors may be (1) reinforced plastic mortar fittings fabricated by the pipe manufacturer from pipe meeting the requirements for soundness specified under "Physical Requirements," (2) cast iron fittings, or (3) fabricated steel fittings. All connections between steel, cast iron, or RPM fittings and RPM pipe shall be made with rubber gasket joints.

All steel fittings shall be protected from corrosion by an epoxy resin coating, as described under Class A coatings under "Irrigation Water Conveyance Pipeline (Steel)," 430-FF.

Dimensions. Length, inside diameter, and wall thickness shall conform to the standards in ASTM-D-3517. Minimum wall thicknesses are given in table 7.

Table 7.—Minimum wall thickness for pipe

Nominal pipe diameter	Minimum wall thickness	
in.	*mm*	*in.*
8	4.32	0.17
10	4.32	.17
12	4.57	.18
14	4.83	.19
15	4.83	.19
16	5.08	.20
18	5.33	.21
20	5.33	.21
21	5.33	.21
24	6.10	.24
27	6.60	.26
30	7.37	.29
33	8.13	.32
36	8.89	.35
39	9.65	.38
42	10.16	.40
45	10.92	.43
48	11.68	.46
51	12.45	.49
54	13.21	.52

Workmanship. The inside surface of the pipe shall be free of bulges, dents, ridges, grooves, or other irregularities that have a depth or a height of more than 1/8 in. as measured from the normal level of the surrounding surface.

Joint sealing surfaces shall be free of dents and gouges that can affect the integrity of the joints.

No glass fiber reinforcement shall be exposed on either the interior or the exterior surface of the pipe.

Markings. Each length of pipe and each reinforced plastic mortar fitting shall bear the size and class of pipe, the date of manufacture, and the name or trademark of the manufacturer.