PIMA COUNTY, ARIZONA

DEPARTMENT OF WASTEWATER MANAGEMENT

STANDARD SPECIFICATIONS

MARCH 1984

REVISED: APRIL 1988
# PIMA COUNTY
## WASTEWATER MANAGEMENT
### PART V
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1. EARTHWORK

1.1 PRELIMINARY

1.1.1 CLEARING AND GRUBBING

Clearing and grubbing shall consist of removing all natural and artificial materials as and when called for on the construction documents. Items to be removed include trees, logs, stumps, brush, grass, weeds, roots, lumber, fences, buildings, rubbish, boulders, and debris.

Clearing and grubbing shall extend to the outside excavation lines, and to a depth of 18 inches below the existing ground surface or to subgrade, whichever is greater. The Engineer may require that the clearing and grubbing operations be performed in advance of grading operations.

Trees and bushes damaged but not removed shall be trimmed and painted as required by the Engineer.

1.1.2 GRADING AND STOCKPILING

Obstructions to surface drainage shall be avoided and alternative drainage facilities shall be provided. Material for backfill shall be neatly placed and kept shaped so as to cause the least possible interference with public travel. It shall also be a sufficient distance back from the edges of the trenches to avoid overloading and prevent slides or cave-ins.
1.1.3 DISPOSAL OF DEBRIS

Debris and excess material shall be removed from the construction zone and disposed of outside of the right-of-way. The Contractor shall make his own arrangements for disposal sites; however, said sites shall be in conformance with all applicable laws, statutes, and ordinances.

1.2 TRENCHES

1.2.1 EXCAVATION

Unless otherwise specified, trench excavations shall be open-cut. The Contractor shall furnish cut sheets, and alignment and elevation stakes at set intervals and offsets. Approved access ladders shall be provided for all trenches deeper than five feet, and shall be located in such a manner that no ladder is more than twenty-five feet from a worker in the trench. Said ladders shall project at least three feet above the top of the trench.

The maximum length of open trench at any location shall be 1,000 feet or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is greater. Unless otherwise specified trenches that cross a street shall be completed as rapidly as possible, and open trenches shall not, at any time, extend across two parallel streets. A trench is considered open until the fill material is placed and compacted to the required densities.

In order to provide the maximum load-bearing capacity, the trench should be as narrow as possible from a point one foot above the crown of the pipe to the grade of the pipe. The requirement is, however, subject to the need for adequate working space in the trench.
For rigid pipe 16-inch nominal inside diameter and smaller, the minimum trench width shall be the pipe outside diameter plus 12 inches, or a maximum trench width of 30 inches. The maximum trench width for rigid pipe larger than 16-inch nominal inside diameter shall be the pipe outside diameter plus 16 inches plus 1/4 the pipe inside diameter. The pipe shall be centered within the trench.

If the trench width at the top of the pipe exceeds the maximum allowable width, additional load-bearing capacity shall be provided by such means as improved bedding, higher strength pipe, or concrete cradles, caps or encasements; subject to the approval of the Engineer. The trench widths cited above shall be measured at a point one foot above the top of the pipe. The trench walls may be sloped or benched one foot above the top of the pipe, but must be vertical below the top of the pipe.

1.2.2 OVEREXCAVATION

Excavation below the specified grade shall be required if the trench bottom consists of unsuitable material. Soft and spongy material shall be excavated to two feet below subgrade; and unyielding material, such as rock and hard caliche, shall be removed to a depth of 1/4 the outside pipe diameter, but not less than four inches and not greater than 12 inches. The cavities thereby created, and cavities created by unauthorized cuts or removal of roots and stumps, shall be filled with the approved backfill material and compacted to 95 percent of maximum density (ASTM 698).

Bell holes shall be excavated below grade so that the pipe is supported along its length and not at the joint. The holes shall be wide enough to provide room for caulking, banding, and bolting, if necessary.
1.2.3. SHORING

When necessary to prevent caving or sliding that might cause injury to the employees or the excavation, trenches shall be properly shored and braced. Concentrated loads and horizontal thrusts shall not be transmitted to the pipe. The Engineer may require that shoring be used, but the Contractor shall be responsible, in all cases, for injuries due to improper or insufficient shoring. Any damage due to settlement, earth or water pressure, slides, caves, or failure or lack of shoring shall be repaired by the Contractor at his expense.

For rigid pipe, removal of shoring, if required, shall be in successive stages to prevent overloading. Cavities remaining after sheets are drawn shall be solidly filled by jetting clean sand. Shoring shall be left in place or cut off in place only if damage might result during removal, or if the pipe strength is insufficient to support the added loads caused by removal. Any damage caused by removal shall be repaired by the Contractor at his expense. No direct payments shall be made for shoring except for the material cost of sheets left in place when so directed by the Engineer.

For flexible pipe, when using moveable trench support, the Contractor shall not disturb the pipe location, jointing or embedment. Removal of any trench protection below the top of the pipe and within 2-1/2 pipe diameters of each side of the pipe shall be prohibited after the pipe embedment has been compacted. For this reason, moveable trench supports shall only be used in either wide trench construction where supports extend below the top of the pipe or on a shelf above the pipe with the pipe installed in a narrow, vertical-wall subditch.
When permitted by the Engineer, any voids left in the embedment material by support removal shall be carefully filled with granular material adequately compacted. Removal of bracing between sheeting shall only be done when backfilling proceeds and bracing is removed in a manner that does not relax trench support. When advancing trench boxes or shields, longitudinal pipe movement and disjointing are not permitted.

1.2.4. BLASTING

Blasting shall be permitted only where one of the following conditions is encountered:

1. Rock, defined as materials which cannot be excavated without drilling and blasting.

2. Boulders larger than eight cubic feet.

3. Earth layers less than 12 inches thick surrounded by rock or boulders.

4. A rate of excavation less than 50 cubic yards per hour with a competent operator using a backhoe with a bucket-curling force larger than 25,000 pounds.

Blasting cannot be conducted without the written permission of the Engineer, who may order the cessation or limit the use of blasting. Additionally, the Tucson City Engineer requires a Blasting Permit when blasting is conducted within the City limits. A minimum of 48 hours prior to blasting, the City of Tucson Police Department Bomb Squad, or the appropriate agency, and any utilities with facilities in the blasting area shall be notified of the intent to use explosives.
Drilling and blasting shall be conducted in a controlled manner so as to avoid the creation of hazardous conditions such as flying debris and excessive vibration. Weighted covering or mats shall be used to confine all materials within the limits of the trench. Materials damaged outside the construction area shall be repaired to the satisfaction of the Engineer and the affected party. Overshooting and the undue loosening or shattering of material shall be avoided. No additional compensation shall be given due to trench enlargement.

1.2.5 DEWATERING

The water table shall be kept at least one foot below the final grade, and trenches shall be kept free of water during the time period beginning prior to excavation and ending upon the Engineer's orders. The Contractor shall construct and maintain the necessary facilities; such as pumps, wells, drains, dams, and channels; to keep the trench dry. If pumps are used, a minimum of one standby pump shall be on the jobsite.

Water removed from the site shall be conducted to drainage facilities without causing damage or disturbance to adjacent property. The Contractor shall be responsible for and shall repair, at his expense, any damage caused by water or protective works. Water levels shall be changed slowly and uniformly so as not to impair the stability of slopes and soil properties. No direct payment shall be made for dewatering.
1.3 BEDDING AND SHADING

1.3.1 MATERIAL

Bedding is defined as the material supporting the pipe. Shading is defined as the material extending from the top of the bedding and extending to one foot above the top of the pipe. The following materials are approved for use as bedding or shading:

1. Crushed stone that meets the following sieve analysis chart:

<table>
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<th>Sieve Designation</th>
<th>Percent Passing</th>
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<tbody>
<tr>
<td></td>
<td>Min.</td>
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<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>90</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>20</td>
</tr>
<tr>
<td>No. 4</td>
<td>0</td>
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<td>No. 8</td>
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Rock and gravel shall be angular, clean, hard, sound, durable and uniform; shall not contain soft, friable, thin, elongated or laminated pieces; and shall be free of deleterious substances such as organic matter, oil, alkali and disintegrated material.

2. Sand material with a maximum PI of 5 and a maximum LL of 30.

<table>
<thead>
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<th>Sieve Designation</th>
<th>Percent Passing</th>
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<tr>
<td></td>
<td>Min.</td>
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<tr>
<td>1 inch</td>
<td>100</td>
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<tr>
<td>No. 4</td>
<td>60</td>
</tr>
<tr>
<td>No. 200</td>
<td>0</td>
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3. Select native soil shall be free of organic material and meet the following sieve analysis:

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<thead>
<tr>
<th>Sieve Designation</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>40</td>
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<tr>
<td>No. 200</td>
<td>0</td>
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<td>Max P.I. = 12</td>
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1.3.2. PLACEMENT OF BEDDING

The standard bedding classes are shown in the Pima County Wastewater Management Department Standard Details. All bedding shall be hand-placed; or placed using a clamshell, backhoe, or front-end loader; uniformly on the trench subgrade. Bedding shall be thoroughly worked under the pipe haunches and placed so as not to displace or damage the pipe.

The bottom of the trench shall be accurately graded to provide firm, uniform, and continuous support between joints.

When crushed stone is used for bedding, little or no compaction is necessary due to the nature of the angular particles. Sand or select native soil used for bedding shall be compacted to 90 percent of maximum density (ASTM D 698) and laid in no more than six-inch lifts.

Sand bedding and Type 1 bedding cannot be used where the water table is above one foot below the trench grade.

For rigid pipe and at depths of cover greater than ten feet, bedding shall be upgraded by one class from the manhole wall to the first joint beyond the transition width of the trench.
1.3.3 PLACEMENT OF SHADING

Shading shall commence after the pipe is placed and such that all pipe laid is protected at the close of each working day.

Pipe shall be shaded to a height of 12 inches above the top of the pipe. Shading shall be carefully placed to protect the line and grade of the sewer. The method of placing the shading shall be in harmony with the involved site/soil conditions.

For Type 1 bedding, select native material as defined in 1.3.1.4 may be used. Mechanical curved head tamper is a method used for consolidating this material in the void spaces under the haunches of the pipe.

1.4 BACKFILL AND COMPACTION

The backfill and compaction shall meet the most stringent requirements of those set forth below and the requirements of the agency with jurisdiction over the right-of-way.

1.4.1 MATERIAL

Backfill is defined as the material used to fill the trench from one foot above the pipe to the land surface. Backfill shall be free of objectionable material such as perishable, spongy and lumpy matter; and broken concrete, asphalt, timber, paper, brush, debris, and rock with any dimension larger than 6 inches. Backfill shall have 60-100 percent passing a 1-inch sieve. Excavated material composed of loose earth or sand meeting these standards may be used as backfill except as modified below.
Where indicated on the plans and when directed by the Engineer, the Contractor shall remove the excavated material and backfill with imported sand or granular soil. Imported sand shall have a minimum sand equivalent of 70. Granular soil shall have a minimum sand equivalent of 20, and 80-100 percent shall be retained on a Number 200 sieve. Imported material shall not be delivered more than ten days prior to use.

1.4.2 CONSTRUCTION

Backfill shall be placed immediately after placing the shading except that no backfill shall be placed around concrete until approved by the Engineer. The trench shall be filled up to the ground surface or to the subgrade of the street. Under no circumstances shall the trench backfill under a street be of less density than the soil prior to excavation.

The standard backfill methods are hand and mechanical compaction. The backfill shall be placed in uniform lifts, moistened if necessary to optimum moisture content, and tamped or rolled. The maximum lift compacted thickness is six inches for hand-directed mechanical tampers and one foot for rolling equipment such as sheepfoot rollers, pneumatic tire rollers, and vibrating equipment. Each lift shall be compacted to the designated density prior to placing the succeeding lift. Mechanical tamping shall not be permitted in the pipe zone.
The Engineer may approve the use of water settling in lieu of hand or mechanical compaction. Water settling shall not be permitted under pavement, in trenches that are not free-draining, or in trenches wider than three feet. Lifts shall not exceed two feet in thickness. Jetting, as a means of compacting the shading and/or backfill material, shall not be allowed when the sewer is comprised of flexible pipe materials, (all diameters; excluding ductile iron pipe) or of rigid materials with an internal diameter of less than 18". In all other cases, the allowance of jetting will be specifically addressed in the project's Special Provisions or Plans. Hand or mechanical compaction shall be used where water settling does not achieve the required densities.

1.4.3 COMPACATION

Densities shall be tested according to AASHTO T-99, METHOD A. The required relative compaction throughout the backfill shall be 95 percent under pavement, or roads to be paved, 90 percent under unimproved street rights-of-way, and 85 percent in alleys and easements. These relative compaction values shall be achieved with the moisture content within three percent of optimum.

1.5 SURFACE PROTECTION AND RESTORATION

1.5.1 PROTECTING STRUCTURES

Existing power and telephone lines, trees, fences, water pipes, gas lines, sewers, curbs, gutters, roadways, driveways, sidewalks, and other sundry structures in the vicinity of the work shall be supported and protected from injury. Any structures that are damaged shall be reconstructed using at least the same kind of material, to
1.5.2 PROTECTING VEGETATION

Vegetation within the limits of construction shall be restored to the original condition when called for on the plans. Vegetation outside the limits of construction shall not be disturbed. If it is damaged, the Contractor shall be responsible for replacement.

1.5.3 FINAL GRADING AND CLEANUP

Pits used for the construction facilities shall be filled, and stockpiles used for construction facilities shall be removed, upon completion of the work. Excess material shall be removed or any shortage imported and the ground surface shall be brought to a neat and acceptable condition not varying more than 0.1 feet from the finished grade elevations indicated on the plans in areas other than pavement.

1.5.4 ASPHALT CUT AND REPLACEMENT

Pavement cutting and replacement shall be as required by the agency with jurisdiction over the right-of-way or as detailed on the plans.

1.5.5 CONCRETE CUT AND REPLACEMENT

Where trenches go through concrete structures such as curbs, sidewalks, gutters, aprons, roadways, and driveways; unavoidable cuts shall be made with a saw approved by the Engineer. Neat, true, and vertical cuts shall follow chalk lines made to mark the sides of the trench. These cuts shall be no less deep than 1/4 the concrete
thickness. Also, cuts shall not be less than 1-1/2 inches deep. There shall be no shatter outside the area of the cut, and any overbreakage shall be repaired at the expense of the Contractor. Concrete shall be immediately disposed of and shall not be allowed in the backfill.

Cuts made in concrete pavement shall not depart by more than one inch in six inches in direction from the original saw cuts. Cuts in a sidewalk or driveway shall be either parallel to the curb or at right angles to the alignment of the sidewalk. No section to be replaced shall be less than 30 inches in either length or width.

If the cut line lies within 30 inches from a joint, the concrete shall be removed and replaced to the joint. A concrete patch in a street paved with concrete shall be at least eight inches thick and at least six inches wider than the trench on both sides. The concrete shall be no less in thickness than the original surface. The replacement concrete shall be of the same or better material, and shall have the same finish, dimensions, and appearance as the original material.

1.6 EARTHWORK FOR STRUCTURES
1.6.1 EXCAVATION

The sides of excavations shall be at least one foot from the widest part of the structure, and may be sloped as required to ensure stable conditions. Excessive moisture must be removed by de-watering. (Section 1.2.5)
When a footing is to rest on rock, the soil shall be removed to expose sound rock. The rock shall be leveled off or cut in approximately horizontal and vertical steps. The surface shall be roughened, and seams in the rock shall be grouted. When the foundation material rests on an excavated surface other than rock, the bottom of the excavation shall not be disturbed, and the final layer of soil shall be removed immediately before placing the concrete. The Engineer may order the removal of unsuitable material and the replacement of it with granular or rock backfill. Unauthorized excavation shall be filled with aggregate base course at the expense of the Contractor.

1.6.2 BACKFILL

Backfill shall not be placed against concrete until permission is given by the Engineer, or the concrete has cured for a minimum of 14 days. All sides of the structure shall be filled to approximately the same elevation at the same time, and wedging action shall be prevented.

Compacting shall be done in less than twelve-inch layers to achieve a maximum density of 95 percent. Approved equipment such as sheepfoot rollers, vibrating rollers, pneumatic rollers, and power rollers greater than 10 tons may be used. The site shall be graded to a neat appearance.
1.7 JACKING AND BORING

1.7.1 MATERIALS

Pipe to be jacked shall be steel-casing pipe designed to resist, without buckling or crushing, the superimposed loads and the horizontal, vertical, and longitudinal loads applied during the jacking operation. Steel casings shall conform to the requirements of Section 3.3.2. The carrier pipe shall conform to the requirements of Section 2.

1.7.2 OPERATIONS

Drawings of the jacking pit bracing, the casing and the jacking head shall be approved by the Engineer prior to commencing jacking operations. Only workers experienced in jacking shall be used. Work shall progress continuously during working hours.

The jacking pit shall be large enough to accommodate men and equipment, and the sides shall be protected by shoring, if necessary. The jacking pit shall be at a location removed from the paving area, and no excavation shall be allowed within 15 feet of the centerline of a railroad track, or of the side slope or shoulder toe of a highway. The end of the pit nearest the road shall present a vertical face.

The position of the jacking frame or guide rails shall be solid throughout the operation so as to maintain the alignment and grade within one inch per 100 feet. The grade shall in no case be less than that shown in the drawing. The backstop shall be perpendicular to the centerline of the pipe and shall have a bearing area capable of supporting 200 percent of the estimated maximum jacking load.
The leading section of the conduit shall be equipped with a jacking head securely anchored thereto to prevent any wobble or vibration. The driving ends shall be properly protected against damage. The pressure developed by the jack shall be evenly distributed on the periphery of the pipe.

The conduit excavation shall not be more than one inch wider than the casing, and no earth shall be lost outside the jacking head. Excavated material shall not be allowed in the conduit, and shall be expeditiously removed from the job site.

Upon completion of the jacking operation, the voids around the outside face of the pipe shall, to the extent practicable, be filled with grout as quickly as possible.

1.8 PILE DRIVING

1.8.1 MATERIALS

Piles shall consist of structural steel shapes that fulfill the requirements of ASTM A 36. The Contractor shall provide certification indicating that the piles conform to all requirements specified.

If the pile is over 60 feet long, two sections may be spliced together, using a full penetration weld around the outside face of the flanges and splice plates of the web as detailed on the plans. The adjacent sections must be properly aligned, and no more than one splice can be made on any pile.
Piles shall be accurately spaced and driven such that the variation from the vertical (batter) is no greater than 1/4 inch per foot. All piles shall be driven to the tip elevation, or deeper if necessary to develop the prescribed bearing value. Piles that are driven offline or damaged shall be removed or cut off, and replaced. If a pile is raised by subsequent driving, it shall be redriven. Excavation in the vicinity of the pile shall be completed prior to driving, and there shall be no excavation below the bottom of the pile footing.

If required by the Engineer, an exploratory pile shall be driven in order to determine the length and penetration required for the balance of the piles. It shall be driven with the same size and type of hammer operating with the same effective energy and efficiency as that to be used for the other piles. No other piles will be driven until the Engineer has analyzed the results from the exploratory pile which may be utilized as one of the piles.

The pile-driving hammer shall meet the following requirements:
1. It shall drive the pile at a penetration rate of at least 1/8 inch per blow at the required bearing value.
2. It shall provide at least one foot-pound for each pound of weight driven.
3. It shall deliver at least 15,000 foot-pounds per blow.
The boiler capacity for steam hammers and the air capacity for air hammers shall be no less than the specifications of the manufacturer. The boiler or compressor shall be equipped with an accurate pressure gauge at all times. Measures necessary to prevent swinging of the hammer and to insure a square delivery shall be taken.

The heads of piles shall be cut squarely. The Engineer may require that a cast or structural steel driving head or cap be used to hold the axis of the pile in line with the axis of the hammer and to prevent excessive upsetting of the pile head under hard-driving conditions.

When necessary to obtain the specified penetration, the Engineer may approve the use of drilling holes within which piles will be placed. The use of water jetting will not be permitted in cohesive soils, or where the stability of the embankments or other improvements may be impaired. The use of a drilled hole shall not diminish the requirement of securing the full bearing and in no case shall the pile be driven less than five feet. The hole width shall not be drilled larger than the largest dimension of the pile. The diameter of a hole drilled for an "H" pile shall be no greater than two inches less than the diagonal measurement of the pile.

The bearing value shall be calculated from the applicable formula in the following schedule:

1. For single-acting steam or air hammers and open-type diesel hammers:

\[
P = \frac{2WL}{s+0.1}
\]

or

\[
P = \frac{2E}{s+0.1}
\]
2. For double-acting steam or air hammers and closed-type diesel hammers:

\[ P = \frac{2L(W+ap)}{s+0.1} \]

or \[ P = \frac{2E}{s+0.1} \]

3. For piles driven to a batter, the safe-bearing value shall be taken as \( U \) times \( P \) where:

\[ U = \frac{0.1(10-M)}{(1+M^2)^{1/2}} \]

**WHERE:**

\( P \) = safe bearing load developed by pile in pounds.

\( W \) = weight of the striking part of the hammer in pounds.

\( L \) = length of stroke or height of fall of the hammer in feet.

\( s \) = average penetration in inches per blow during the last 10 to 20 blows.

\( E \) = manufacturer's rating of energy developed by hammer in foot-pounds.

\( a \) = effective area of the piston in square inches.

\( p \) = mean effective pressure (steam or air) in pounds per square inch.

\( M \) = tangent of the angle of batter.

These formulas are only accurate when:

1. Penetration is at a quick and uniform rate.
2. The lifting line is slack.
3. There is no additional bounce after the blow. Twice the height of the bounce shall be deducted from "\( L \)" to determine the true value.
4. A follower is not used.
The Engineer may require that a loading test be performed on one or more of the involved piles. The pile shall be considered to have a bearing value equal to the design load if the permanent settlement produced by the continuous application of a load of twice the design load is not greater than 1/4 inch. This test, if required, shall be performed on an exploratory pile more than 24 hours after it is driven, and no other piles shall be driven pending the results. The load shall be removed no sooner than 24 hours after deflection ceases and in increments as directed by the Engineer. The Contractor shall provide suitable facilities and equipment to conduct the test. Payment for the tests shall be as outlined in the contract documents proposal.

The pipe shall be fastened to the top of the pile according to the Pima County Wastewater Management Department Standard Details, or as approved by the Engineer.
2. PIPE MATERIALS AND INSTALLATION

PREFACE

NEW MATERIALS

Only those materials specified herein shall be utilized to construct public sanitary sewerage system facilities. Other materials shall be utilized only upon pre-qualification through the following procedure:

a. Submittal to Wastewater Management of sufficient data pertaining to the material's composition, strength, durability, etc.; including information on other installations or applications, and

b. Acceptance by the Wastewater Management Department of the information provided, and

c. Approval by the Chief Engineer of the Wastewater Management Department to utilize the material on a "test case" basis only, at one or more designated locations.

Inclusion of a material in these Standard Specifications can only occur upon the written recommendation of Wastewater Management and, thereafter, the approval of such an inclusion by the County's Development Standards Committee, via an amendment to the Standard Specifications.

All sewer pipe and pipelines shall meet both the general specifications set forth in Section 2A, and the specifications specific to the particular pipe material set forth in Section 2B for gravity lines, or 2C for pressure lines.
A. GENERAL

2.1 MANUFACTURE

2.1.1 QUALITY OF PIPE

A certification from the manufacturer shall be furnished attesting that the pipe meets the requirements of this Section (2). All pipe shall be clearly marked with the name or trademark of the manufac-
turer, and the location of the plant.

2.1.2 REPAIR

Repairs shall be allowed according to the sections herein specific to the pipe material (Sections B and C).

2.1.3 APPURtenANCES

Fittings shall correspond in all respects with the requirements specified for pipe of the corresponding size.

Fittings shall be made to such lengths as will accommodate the joining system provided. Tee and wye fittings shall be furnished with spurs of the size specified, securely and completely fastened to the barrel of the fitting in the process of manufacture.

The spurs of tee fittings shall have their axes perpendicular to the longitudinal axis of the fitting. The spur of the wye fittings shall have their axes at angles of approximately 45 degrees to the longitudinal axis of the fitting, measured from the socket or bell end of the fitting. The barrel of each spur shall be of sufficient length to permit making a proper joint.

Spurs shall not project inside the inner surface of the barrel. The barrel of each spur shall be of sufficient length to permit making a proper joint with the connecting pipe.
Plugs shall be furnished and installed in all branch spurs that are left unconnected and at the upper end of each house connection sewer. The plugs shall be strong enough to sustain all applied earth and hydrostatic loads including those due to field hydrostatic tests or air tests.

Plugs for branch pipes having flexible compression joints may be either clay discs with flexible compression joints, factory applied, that will mate with the branch joint; or a resilient material of controlled design and dimensions for mating with the branch pipe to which it is to be applied; or of other material approved by the Engineer. Plugs shall not be adversely affected when exposed to chemical and bacteriological environments. When installed and braced in place in branch spurs, plugs shall withstand a hydrostatic pressure test of 10 psi with no leakage.

2.2 INSTALLATION

2.2.1 HANDLING AND STORAGE

Pipe and appurtenances shall be handled in such a manner as to insure delivery to the trench in sound and undamaged condition. All pipe shall be unloaded opposite or near the location at which it will be installed. The pipe shall not be stored upon a residential street for more than ten days or upon a business street for more than three days. The interior of the pipe shall be thoroughly cleaned of foreign material before being lowered into the trench.
2.2.2 LAYING AND JOINING

The laying of the pipe shall be in finished trenches free from water and debris, and shall be commenced at the lowest point of the system with the spigot ends pointing in the direction of the flow. Each pipe shall be laid true to line and grade, with uniform support under the full length of the pipe barrel.

Pipe sections shall be laid and joined in such a manner that the offset of the inside of the pipe at any joint will be held to a minimum at the invert. The maximum offset at the invert of pipe shall be one percent of the inside diameter of the pipe, or 3/8 inch, whichever is smaller.

Upon installation, the meeting surfaces shall be wiped clean of dirt and foreign matter, then an approved lubricant shall be applied at the joint surfaces. The spigot shall be positioned inside the socket and the installation completed.

Any adjustment of line and grade shall be made by scraping away or filling in under the body of the pipe, never by wedging or blocking under the pipe ends.

Whenever work is not in progress, open ends of the pipe shall be securely closed so that no water, earth or other substance will enter the pipe or fittings. If, prior to testing, any debris is found in the pipe, the pipe shall be cleaned by propelling with water a snug-fitting inflated ball through the pipe or by using other adequate methods.
2.3 TESTING

2.3.1 LEAKAGE AND INFILTRATION

Sewer pipelines shall be tested for leakage or infiltration following the placement of the final backfill and densification.

In the case of new sewer lines with house connections included as an integral part of the project, the test shall be performed after the house connections and stubs have been completed and backfilled. In the case of replacement sewer lines, the test shall be as specified in the special provisions.

For gravity sewers, whenever the ground water level is at or above the top of the pipe, the water infiltration or the air test shall be used. Otherwise, for gravity sewers, either the exfiltration test or the air pressure test shall be used. The water pressure test shall be used for pressure sewers.

Exfiltration Test

Each section of sewer shall be tested between successive manholes by closing the lower end of the reach of sewer to be tested with a plug, and closing the outlet sewer of the upper manhole with a plug and stand pipe. The pipe and house connections shall be filled with water through the stand pipe to a point four feet above the invert of highest house connection sewer. All the involved house connection sewers must be purged of air prior to measuring the water loss. After the water in the pipeline has been maintained for such time as required to compensate for the water loss by absorption by the pipe material, the drop in the stand pipe is measured. The water loss shall not exceed 200 gallons per day per mile per inch of internal diameter of mainline pipe.
Exfiltration Test - Water Loss Determination Procedure

1. The Exfiltration Test Chart below shall be used to determine that water loss does not exceed the maximum allowable.

**EXFILTRATION TEST CHART**

Water Test Data - Rate of fall in stack for 200 Gal/inch/mile/day.

Maximum Rate of Fall - Inches per Minute for 1000' Run

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<th>8&quot;</th>
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NOTE: Multiply these figures by the length in feet of the run being tested and divide by 1000 to obtain maximum allowable fall per minute.
Infiltration Test

Prior to performing an infiltration test, the end of the reach of sewer to be tested shall be plugged at the upper manhole structure and all pumping of groundwater from out of the involved reach of pipe shall be discontinued for at least three days. Using a weir or other suitable device at the lower end of the reach in question, the infiltration rate shall be measured and recorded at the end of the noted three (3) day period. The rate of infiltration recorded shall not exceed 200 gallons per day per mile per inch of internal diameter of pipe.

Air Test

Testing shall be done in accordance with ASTM C828-80, or as modified herein. The basic procedure is as follows:

1) Determine the test time for the section of line to be tested see procedure noted below.

2) Plug all openings in the test section.

3) Add air until the internal pressure of the line is raised to approximately 4.0 psi. After this pressure is reached, allow the pressure to stabilize. The pressure will normally drop as the air temperature stabilizes. This usually takes two to five minutes, depending on the pipe size. The pressure may be reduced to 3.5 psi before starting the test.

4) When the pressure has stabilized and is at or above the minimum required starting test pressure of 3.5 psi, start the test. If the pressure drops more than 1.0 psi during the test time, the line is presumed to have failed the test. If a 1.0 psi drop does not occur within the test time, the line is considered to have passed the test.
Air Test-Time Determination Procedure

1) Table 1 shows the required test time, \( T \), in minutes/100 feet of pipe for each nominal pipe size. Test times are for a 1.0 psi pressure drop from 3.5 to 2.5 psi.

2) If the section of line to be tested includes more than one pipe size, calculate the test time for each size and add the test times to arrive at the total test time for the section.

3) It is not necessary to hold the test for the whole period when it is clearly evident that the rate of air loss is less than allowable.

**TABLE 1 - Minimum Test Time for Various Pipe Sizes**

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<tr>
<td>18</td>
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</table>

**Pressure Test**

All pipe for use as a force main shall be hydrostatically tested for leakage. Care shall be taken to insure that all air vents are open during filling. After the piping is completely filled, it shall be allowed to stand under a slight pressure for sufficient time, at least 48 hours, to allow the escape of air from any air pockets. During this period, bulkheads, valves, and connections shall be examined for leaks. If any are found, they shall be repaired prior to final...
pressure testing. The final test shall consist of holding 150 psi for a period of four hours with leakage less than 15 gallons per inch of diameter per mile of pipe per 24 hours.

2.3.2 ALIGNMENT AND DAMAGE

After the pipe has been laid and tested, the pipe shall be visually inspected (mirrored) for alignment and grade, and for damage and defective pipe. Any pipe which fails inspection shall be taken up and relaid at the expense of the Contractor.

B. GRAVITY PIPE MATERIALS

a. VITRIFIED CLAY PIPE (VCP)

2.1 MANUFACTURE

Except as modified herein, all materials, manufacture and testing for VCP shall be in accordance with ASTM C 700.

2.1.1 QUALITY OF PIPE

Materials

VCP shall be new and extra strength in accordance with the requirements set forth in ASTM C 700, and meet the requirements set forth below.

Dimensions and Tolerances

The dimensions and permissible tolerances for the laying length, squareness of ends, and variation of inside diameter of VCP shall conform to Table 2 of ASTM C 700.

The inside diameter shall not vary from a true circle by more than three percent of its nominal diameter. The average inside diameter shall be determined by taking any two 90° opposing measurements and averaging the readings.
The pipe shall not deviate from straight by more than 1/16 inch
per foot of length when the offset is measured from the concave side of
the pipe. Measurement shall be taken by placing a straightedge of the
concave side of the pipe's full length of the barrel, being sure not to
include spigot joint material or socket, and measuring the maximum
distance between the straightedge and concave side of pipe.

Imperfections

Pipe of nominal sizes from three to 18 inches shall have no
blister with a dimension exceeding three inches and no blister or
pimple shall project more than 1/8 inch above the surface of the pipe.
Pipe of nominal sizes over 18 inches shall have no blister exceeding
two inches per foot of internal diameter, and no blister or pimple
shall project above the surface of the pipe more than 1/8 inch per foot
of internal diameter. The pipe shall have no broken blisters.

There shall be no fractures or cracks passing through the barrel
or socket, except that a single crack at the spigot end of the pipe not
exceeding 75 percent of the depth of the socket, or a single fracture
in the socket not exceeding three inches around the circumference nor
two inches lengthwise, may be permitted. Chips or fractures on the
interior of the pipe shall not exceed two inches in length, one inch in
width, and a depth of one fourth of the thickness of the barrel. A
single pipe shall contain no more than two such defects.

Testing

VCP shall meet the crushing strength and acid resistance tests,
and either the adsorption or hydrostatic pressure test using the cri-
teria set forth in ASTM C 700 and the testing procedures set forth in
ASTM C 301.
2.1.2 REPAIR

Prior to installation, VCP can be repaired under the circumstances set forth below using the methods described below.

Allowed

Clay pipe larger than 15 inches in diameter which is structurally sound may be repaired. These repairs include the cleaning out of the cracks, the preparation of the chipped surface, and the application of repair material.

Longitudinal cracks parallel to the axis and described below may be repaired, provided they were caused by shrinkage or drying and are not more than 1/32 inch wide:

1. Cracks on the exterior of the spigot that do not penetrate the entire barrel thickness and do not exceed 50 percent of the depth of the socket in length.

2. Cracks in the socket of the pipe that do not penetrate the entire thickness, and do not exceed 75 percent of the depth of the socket in length.

3. Cracks in the socket of the pipe that penetrate the entire thickness of the socket and do not exceed 50 percent of the depth of the socket in length.

4. Cracks in the interior of the socket and in the shoulder on the exterior of the socket which do not exceed three inches in length, and do not penetrate more than 20 percent of the wall thickness.
Surface chips located on the exterior of the spigot, the interior or exterior of the socket, or on the shoulder of the socket may be repaired provided:

1. The length of the circumference of the chip does not exceed twice the barrel thickness.
2. The width is not greater than 50 percent of the socket depth measured parallel to the axis.
3. The depth is not greater than 25 percent of the wall thickness measured perpendicular to the axis.

Full-depth chips located on the socket may be repaired provided the length of the chip does not exceed twice the barrel thickness or the width does not exceed 25 percent of the socket depth.

Method

Repairs of any type at the spigot or socket shall be limited to one for each 60 degrees of circumference and a maximum of four at either end. No repairs will be permitted on pipe to be used for fabrication of fittings unless the repaired pipe is tested. However, fittings may be repaired within the scope of these specifications.

All surfaces to be repaired shall be clean and dry. All unsound material at lumps or blisters shall be ground smooth and flush with adjacent surfaces. Cracks shall be saw cut, ground or otherwise grooved 1/3 inch to 1/4 inch wide and 1/8 inch to 1/4 inch deep for the full length of the crack and then cleaned of all loose material. All unsound material such as chips, flakes, pits, and spalls shall be removed. Edges shall be chipped or ground 1/16 inch minimum below adjacent surfaces. There shall be no feather edges.
Materials used for repair shall be approved by the Engineer. Repair material shall be mixed, applied, and cured as recommended by the manufacturer and approved by the Engineer, and shall have a color contrasting with the color of the pipe to be repaired. If necessary to produce a contrast in color, carbon black in a small quantity may be added to the repair material.

Repair material shall be compounded to provide properties most desirable for sewerage service. Repair material shall resist bacterial attack and attack by chemicals or combinations of chemicals normally present in domestic and industrial sewerage.

**Tests**

The repair material shall be subject to the following tests:

1. Vitrified clay bars one inch square in cross section and approximately eight inches in length, compounded of the same materials as the vitrified clay pipe and fired to clay pipe manufacturing temperature, shall be used in preparing the test specimens. The Bars shall have a modulus of rupture of not less than 1,600 psi when tested in flexure with three-point loading. The bars shall be cut through at the mid-point and then bonded with the repair material. Following a seven-day maximum cure period at ambient room temperature, the bonded bars shall be tested in flexure with three-point loading. The average modulus of rupture of five test bars bonded with the repair material shall be not less than 1,600 psi.
2. Five additional test bars bonded with repair material and immersed for 60 days in water at ambient room temperature shall have an average modulus of rupture not less than 1,500 psi.

Each specimen of repair material shall lose not more than 2.0 percent of its weight when immersed in the solutions listed below for a period of 30 days. Specimens shall be conditioned for seven days at 110°F and cooled in a desiccator for three hours prior to weighing.

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>PERCENT CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfuric Acid</td>
<td>20*</td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>5</td>
</tr>
<tr>
<td>Ammonium Hydroxide</td>
<td>5*</td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>1*</td>
</tr>
<tr>
<td>Ferric Chloride</td>
<td>1</td>
</tr>
</tbody>
</table>

  * Volumetric percentages of concentrated C.P. grade reagents.

All pipe permitted to be repaired shall be inspected after preparation and prior to repair (to determine what repairs are to be made) and after the repair has been made.

Pipe having unauthorized repairs will be rejected. The Engineer may require retesting of any repaired pipe to demonstrate its soundness. The Engineer will supervise all repairs and inspections required by this subsection. The Department shall be reimbursed for all costs incurred for inspection and testing of the repaired pipe.
2.1.3 APPURTENANCES

Joints for VCP shall be bell and spigot or plain end, and shall meet the requirements of ASTM C425. The bell and spigot shall not vary from a true circle more than three percent of its nominal diameter. The bell shall be concentric with the barrel of the pipe. The sealing components shall resist attack by chemicals or combinations of chemicals normally present in domestic or industrial sewage, and shall resist bacterial attack.

Compression couplings shall incorporate continuous and internally positioned corrosion resistant shear rings. Coupling components shall be made of stainless steel of the following type:

- **Clamps**: 300 Series, Type 316
- **Bolts**: 300 Series, Type 305
- **Nuts**: 300 Series, Type 305

The clamps at both ends of the couplings shall be the "field take-up" type.

Fittings and stoppers shall meet the hydrostatic pressure testing requirements of the ASTM C 700 using the testing procedures of ASTM C 301. Joint shall not leak when subjected to the deflection, shear, and displacement tests as described in ASTM C 425.

2.2 INSTALLATION

The first joint of VCP directly connected to or supported by a rigid structure shall be no more than one foot-six inches from the wall of the structure.
b. **DUCTILE IRON PIPE (DIP)**

2.1 **MANUFACTURE**

Except as modified herein, all materials, manufacture, and testing for DIP shall be in accordance with ASTM A 746.

2.1.1 **QUALITY OF PIPE**

DIP shall be manufactured with the material, have the dimensions, be within the tolerances, and meet the testing requirements set forth in ASTM A 746. **DIP shall be manufactured in nominal 18-foot or 20-foot laying lengths** and shall have one of the two kinds of lining listed below.

2.1.2 **LINING**

1. Polyethylene lining (for 8"-54" DIP and fittings)

Polyethylene lining material shall be virgin polyethylene complying with ANSI/ASTM D 1248, compounded with or without an inert filler and with sufficient carbon black to resist ultraviolet rays during aboveground storage of the pipe and fittings. The polyethylene shall be bonded to the interior of the pipe and fittings by heat.

The polyethylene lining shall cover, as a minimum, the inner surfaces of the pipe and fittings from the plain or beveled spigot end to the edge of the gasket socket. However, the lining extending into the gasket socket area and onto the exterior of the spigot end of the pipe can be either polyethylene or coal tar epoxy.

All polyethylene lining shall be done by the pipe manufacturer at the location of the manufacture of the pipe.

Any coal tar epoxy used in conjunction with the polyethylene lining shall meet the specifications listed in 2.1.2.2.
2. Coal Tar Epoxy Lining (For 4" - 54" DIP and fittings)

Coal Tar Epoxy Lining compound must be a two-component coal tar epoxy compound capable of at least 40 mils dry film thickness in an application process whereby delamination will not occur. The material must also meet the following minimum performance requirements:

a. A direct impact resistance as measured by ASTM D 2794 at 35 mils dry film thickness on ductile iron panels. The material shall pass 60 inch-pound of impact.

b. An abrasion resistance of 20 liters per mil as measured in ASTM D 968.

c. The coal tar epoxy used shall meet the requirements of DOD-P-23236A (SH), Type I, Class ii, except as modified by the specifications of Pima County Wastewater Management.

All Coal Tar Epoxy lining shall be done by the pipe manufacturer at the location of the manufacture of the pipe, or by a qualified applicator selected and inspected by the pipe manufacturer to do the lining at his place of business. He shall have a five-year history of doing this particular type of lining for ductile iron or steel pipe.

3. General Conditions

The pipe manufacturer shall be solely responsible for both the quality of the pipe and the quality of the lining. All surface areas which will be exposed to sewer liquids and gases shall be cleaned so as to remove all deleterious materials. After cleaning, the lining compound shall be applied to all surface areas which will be exposed to the sewer liquids and gases. The lining compound shall be applied so as to obtain a continuous and relatively uniform and smooth integral lining.
The lining in the barrel area shall have a nominal thickness of 40 mils and a minimum thickness of 35 mils. However, the lining in the bell area may transition from a 35 mil minimum thickness at the edge of the barrel area to a 10 mil minimum thickness at the edge of the gasket socket. The 10 mil lining shall extend into the gasket socket area to a point where the gasket would overlap the lining when it is compressed due to pipe assembly during construction. The 10 mil lining shall also continue from inside the barrel area, around the spigot end of the pipe and along the outside of the pipe to a point where the center of the gasket of the next pipe to a point where the center of the gasket of the pipe section would contact the edge of the lining on the spigot end of the previous pipe section. This is a minimum requirement. The thickness of linings shall be determined by using a dry film thickness magnetic guage.

Lining material must pass the following immersion tests (35 mil minimum dry film thickness) without disintegration, blistering, or cracking:

<table>
<thead>
<tr>
<th>TEST</th>
<th>TEMPERATURE</th>
<th>DURATION (HOURS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Sulfuric Acid</td>
<td>70°F</td>
<td>432</td>
</tr>
<tr>
<td>36% Hydrochloric Acid</td>
<td>70°F</td>
<td>720</td>
</tr>
<tr>
<td>3% Sulfuric Acid</td>
<td>112°F</td>
<td>-</td>
</tr>
<tr>
<td>25% Sodium Hydroxide</td>
<td>112°F</td>
<td>-</td>
</tr>
</tbody>
</table>

Each piece of pipe shall be tested and shall have an absence of holidays when tested by a suitable holiday detector. In all cases, the barrel area of the pipe shall be tested using both a voltage of 7500 volts and a dry conductive probe. When coal tar epoxy is used in the bell area or on the exterior of the spigot end, that area shall be tested using both voltage of 67.5 volts and a wet sponge.
The pipe manufacturer shall issue a certification that states that the pipe and the lining meet the standards and specifications of the Pima County Wastewater Management Department. This certification shall state specifically the following things:

a. All ductile iron pipe and fittings have a polyethylene (or coal tar epoxy, as appropriate) interior lining of 40 mils (35 mils minimum) in the barrel area, 10 mils minimum in the bell area and 10 mils minimum on the exterior of the spigot end.

b. Each piece of pipe and each fitting have been checked for holidays utilizing a testing voltage of 7500 volts with a dry conductive prove in the barrel area and testing voltage of 67 1/2 volts with a wet sponde in both the bell area and the exterior of the spigot end, and no holidays were found.

c. The polyethylene or coal tar epoxy lining shall extend from the bottom of the gasket socket in the bell to a point on the exterior of the spigot end of the pipe where the next pipe gasket would overlap the lining.

d. All polyethylene and coal tar epoxy used meets the current specifications set by Pima County Wastewater Management for this material.

When pipe is supplied that cannot meet the certification requirements for holiday testing and minimum lining thickness in the bell area or on the exterior of the spigot end, neoprene caulking will be required when the pieces of the pipe are assembled during construction.

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The caulking must be applied in sufficient quantity and at the proper location such that when the spigot end of the pipe is inserted into the bell end of another pipe, an impermeable seal is developed between the spigot end of one pipe section and the barrel to bell transition point of the other pipe section. The use of this caulking is only a substitute for certifications dealing with holidays and lining thickness in the bell area and the exterior of the spigot end. All other certification requirements must be complied with. It should also be noted that Pima County Wastewater Management may require the use of neoprene caulking during construction of all DIP when deemed appropriate.

If the contractor makes a field cut of polyethylene or coal tar epoxy lined pipe, he shall comply with the recommendations of the pipe manufacturer in applying a coal tar epoxy coating to the pipe end and in allowing proper drying time before pipe assemble. In all cases, as a minimum, a 10 mil coating of coal tar epoxy shall be applied to the pipe end and shall overlap the polyethylene or coal tar epoxy lining by four inches and extend around the end of the pipe and along the outside of the pipe a minimum of three inches and shall also be allowed to dry before pipe assemble. In addition, the overlapped surface of the polyethylene or coal tar epoxy lining shall be roughed up to produce a 3 to 5 mil profile over the entire surface. The end result of this process is to secure proper adhesion for the coal tar epoxy.

Holiday testing may be required by Pima County Wastewater Management after pipe assemble when deemed appropriate. The testing and repair requirements shall follow the procedures called for in these specifications.
2.1.3 Repair

Repair of the damaged sections of the coal tar epoxy and polyethylene lining shall be in accordance with the lining manufacturer's recommendations or as specified in 2.1.2.3, so that the repaired area is equal to the undamaged lined area in all respects. All damaged lined areas and holidays shall be repaired immediately.

There will be no other provisions for repair of DIP.

2.1.4 Appurtenances

Fittings and stoppers shall meet the requirements of ANSI a 21.10. Joints shall be push on type and meet the requirements of ANSI a 21.11. Neoprene rubber gaskets shall be used for all DIP, unless the plans state otherwise.

2.1.5 Polyethylene Encasement for DIP

For protection in the isolated areas of severely aggressive soils, AWWA C 105 covers materials and installation procedures for polyethylene encasement of underground installations of DIP.

Polyethylene wrap in tube or sheet form for piping encasement shall be manufactured from virgin polyethylene material conforming to the requirements of ANSI/ASTM standard specification D 1248. The specified minimum nominal thickness is 0.008 inches (8 mils). The minus thickness tolerance shall not exceed 10 percent of this nominal thickness.

Material and installation methods shall be in accordance with the requirements of AWWA C 105.

2.1 MANUFACTURE
2.1.1 QUALITY OF PIPE

MATERIALS

Before starting manufacture of RCP, the Contractor shall submit to the Engineer detailed shop drawings of the pipe, joints, reinforcement cage assemblies, pipe specials, and the pipe-laying diagrams. The laying diagram shall show the location, length, design designation, and number designation of each pipe section and pipe special.

The D-Loads specified in the Plans and Specifications are those to produce a 0.01 inch crack at the interior pipe surface.

The reinforced concrete pipe will meet the requirements of ASTM C 76 Portland cement shall be Type II unless otherwise specified by the Engineer and conform to the requirements of ASTM C 150.

After the concrete materials have been mixed, they shall be promptly placed in the forms and spun on a horizontal axis. If, for any reason, the work of filling the forms is interrupted long enough for the concrete to take its initial set, any partly filled form shall be emptied and the concrete rejected. While the concrete is being placed in the forms, they shall be revolved on a horizontal axis at a speed that will ensure a minimum centrifugal force of 20 g's. After all the concrete has been placed in the forms, the forms shall be revolved and vibrated at the proper speed for a sufficient length of time to secure as dense a concrete as possible, and the interior surface shall be made smooth. Water and laitance collecting on the surface of the concrete shall be removed, and the interior surface of the pipe shall be troweled and finished to the form of a true cylinder of the internal diameter specified.
Lined pipe shall meet the requirement of ASTM C 76 having o-ring rubber gasket joints with an interior lining of plastic-liner plate except when otherwise permitted by the Engineer. No materials shall be used in manufacturing of the pipe other than water, Type II Portland cement as specified in ASTM C 150, and mineral aggregates and steel conforming to ASTM C 76.

Suitable devices shall be used to hold the cage of reinforcement in its elliptical or circular shape and to maintain the cage in place within the forms during the placing and consolidation of the concrete. Supports between the reinforcement and the forms that are to be exposed in the finished pipe shall be made of stainless steel.

The interior area of RCP shall be sealed with a protective lining installed by the pipe supplier. The material used in the liner plate shall be a combination of inert, synthetic resins, pigments, and plasticizers, compounded to make permanently flexible sheets.

The liner plate shall be resistant to oxidizing agents; sulfuric, phosphoric, nitric, chromic, oleic, and stearic acids; sodium and calcium hydroxides; ammonia; sodium, calcium, magnesium and ferric chlorides; ferric sulfate; petroleum oils and greases; vegetable and animal oils; fats; greases; and soaps. The liner plate shall be impermeable to sewage gases and liquids, and shall be nonconductive to bacterial and fungus growth. All liner plates shall be factory checked.
electrically with a high-voltage Holiday detector set at 15,000 to 20,000 volts to insure freedom from any porosity. The lining shall have good impact resistance, shall be flexible, and shall have an elongation sufficient to bridge up to a 1/8-inch settling crack without damage. Once cast into the pipe, the lining shall be permanently and physically (not adhesively) attached by the T-lock mechanism. The lining shall withstand a 40-psi back hydrostatic pressure applied to the under surface of the lining without losing anchorage or without rupture or leakage.

Cement shall be stored in weathertight, dry, and well-ventilated structures approved by the Engineer. Cement containing lumps will be rejected and shall immediately be removed from the site of work. The proportion of Portland cement in the mixture shall be not less than 564 pounds per cubic yard of concrete.

The pipe manufacturer shall certify in writing that no calcium chloride has been used in the manufacture of the pipe. Other admixtures may be used if approved by the Engineer.

The aggregates shall be so graded, proportioned, and thoroughly mixed to produce a homogenous concrete mixture of such quality that the pipe will conform to the test and design requirement of this specification.

The reinforcement shall be fabricated as a rigid cage of bars or wire. Transverse reinforcement shall be fabricated either as complete hoops, welded or lapped, or as a continual helix. If the transverse reinforcement is formed as a cylindrical or elliptical helix, both ends
of the cage shall be finished off as a complete hoop. The location of
the minor axis of elliptical reinforcement shall be clearly marked
using a letter "T" painted or stamped on the inside of the pipe.

Splices shall be either welded or lapped and tightly wired.
Either lap or butt welds may be used, but the weld must develop the
full strength of the bar. The lap of unwelded splices shall extend 30
diameters when bars or rods are used for reinforcement, and 40 dia-
meters when wire is used.

RCP can be steam-cured or water-cured. Steam curing shall not
commence until the concrete has attained its initial set, but in any
event not sooner than one hour nor later than eight hours after placing
of the concrete. The manufacturer shall provide adequate steam plant,
piping, enclosures, and other facilities for curing the pipe. The rate
of temperature rise shall not exceed 30° per hour. The enclosures
shall be such that the temperature is maintained continuously between
110° and 150° F. The pipe shall be cured until design strength is
reached (at least 90 hours), but after six hours the forms can be removed.

Water curing will be accomplished either by keeping the pipe
constantly and completely wet with fog sprays during the daylight
hours, or by keeping the pipe moist during the daylight hours and
covering the pipe and ends with a burlap.

Dimensions and Tolerances

RCP shall have a nominal laying length of 8 to 20 feet unless
otherwise specified. The internal diameter of any portion of pipe
shall not vary more than one percent, but in no case shall the variance
exceed 3/8 inch from the nominal diameter. The pipe wall may be thicker than the design, but cannot be less than the design by more than five percent or 3/16 inch. Variation in laying lengths of two opposite sides of pipe shall not be more than either 1/8 inch per foot of diameter or 5/8 inch total. The underrun in length of a section of pipe shall not be more than 1/8 inch per foot with a maximum of 1/2 inch in any length of pipe.

The placement of reinforcement steel shall not vary from the position in the pipe wall shown on the drawings by more than 1/4 inch. In no case shall the cover over reinforcement be less than one inch.

Each pipe shall have a minimum longitudinal reinforcement equivalent to 1/2-inch round deformed steel rod at a maximum spacing of 18 inches. Also, such reinforcement shall provide a ratio of 0.0020 reinforcement area to gross concrete area. Where two cages are used, the longitudinal reinforcement shall be divided approximately equally between the two cages, and only the longitudinal bars on the outer cage need extend into the bell. The end hoops of the transverse reinforcement will not be more than one inch from the extreme end concrete faces of the pipe. For pipe with a wall thickness of 2-1/4 inches or less, the transverse reinforcement shall be located at the center of the wall. The cover over longitudinal reinforcement shall be at least 3/8 inch.

The liner plate shall not be less than 0.065 inches in thickness. Locking extensions shall be of the same material as the liner and shall be integrally extended with the sheets. If steel bands are used to secure the liner plate to the forms transversely, strap channels shall be integrally molded into the sheet.
Liner plate shall be supplied as pipe-size sheets fabricated by shop welding together the basic-size sheets. Joint straps shall be 4.0 inches (+ 0.25 inches) in width and shall have each edge beveled prior to application. Welding straps shall be 1.0 inch (+ 0.25 inches) in width and shall have the edges beveled at the time of manufacture.

Each day's run shall be marked and stored in any manufacturer's yard so that the pipe made on any particular day may be easily identified. The date of manufacture, size and D-load, lot number, manufacturer's identification mark, and, where elliptical reinforcement is used, a four-inch high "T" marking the location of the minor axis of the reinforcements, shall be legibly painted or stamped on the inside of each pipe.

All pipe shall be manufactured, handled, loaded, and shipped in such a manner that it will be delivered undamaged in sound condition and conforming in all respects to these Specifications.

Imperfections

A section of RCP may be rejected because of any of the following:

1. Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
2. Defects that indicate imperfect proportioning, mixing, and molding.
3. Surface defects indicating honeycombed or open texture.
4. Damaged or cracked ends where such damage would prevent making a satisfactory joint.
5. Any continuous crack having a surface width of 0.01 inches or more and extending for a length of 12 inches or more, regardless of position in the wall of pipe.

6. Any crack showing two visible lines of separation for a continuous length of two feet or more, or an interrupted length of three feet or more anywhere in evidence, both inside and outside. When required by the Engineer, any crack which is 0.01 inch wide or wider and is not a cause for rejection, shall be filled with neat cement grout composed of cement mixed with water to a fluid consistency.

7. Any crack that goes completely through the pipe.

8. Shattering or flaking of concrete at a crack.

9. Bubble voids on the pipe surface exceeding 1/4 inch in depth (unless pointed with mortar).

10. Blisters at pipe joints involving more than 1/4 the interior surface area, and any unrepaired blister.

11. A piece broken from the end projections of the pipe which has circumferential length exceeding 60 degrees of the circle, or extends into the gasket contact surfaces of gasketed joint pipe for a circumferential length in excess of six inches (measured at the midpoint of the gasket contact surface on the bell end and at the inner shoulder of the gasket groove at the spigot end). If two or more pieces are broken from an end projection, the total length of such broken pieces on any end shall not exceed 90 degrees of the circle and there shall
be a distance of at least nine inches of sound concrete between breaks. The total length of broken pieces that extends into the gasket contact surfaces of gasketed joint pipe shall not exceed a circumferential length of six inches. If less than nine inches of sound concrete exists between two individual breaks, the two breaks shall be considered as one continuous break. Repair of such defects not exceeding the above limitations shall be made as described in Section B.d.2.1.2. Unsound portions of end projections shall be removed and, if the pieces removed do not exceed the above limits, the pipe may be similarly repaired.

Testing

The pipe shall meet the physical requirements set forth in Section 9 of ASTM C 76.

All liner shall be shop tested for holes, using an approved spark detector SET AT A MINIMUM OF 20,000 VOLTS. Sheets having holes shall be satisfactorily repaired in the shop and retested prior to shipping to the project.

1. D-Load Bearing Strength Test

Pipe to be D-load tested shall be randomly selected at the point of manufacture by the Engineer. One pipe will be selected for each lot, or fraction thereof, of the pipe to be furnished for the project.
For the purpose of these specifications, a lot is defined as 600 feet, but no more than 50 sections of pipe, or a fraction thereof, of one size and class manufactured on consecutive working days. If the 600 feet, but no more than 50 sections, of pipe are not made on consecutive working days, then only those made on consecutive working days shall be considered a lot. If an interruption in the manufacture of a lot occurs, the Engineer may permit the pipe made after the interruption to be included in the lot, provided the interruption does not last more than seven calendar days. A new lot number will be assigned if any change occurs in the size or spacing of reinforcing steel, in the concrete mix, or in the curing method.

The Contractor or pipe manufacturer shall furnish the test pipe without charge and shall provide adequate equipment and facilities for conducting tests and shall bear all expense in connection therewith. All tests shall be under the supervision of the Engineer. All testing equipment shall be calibrated at intervals not to exceed six months by an agency approved by the Engineer.

Test pipe shall conform in all other respects to the applicable requirements specified herein. Pipe shall be tested by the three-edge bearing test as described in ASTM C 497.
The required strength of the pipe specimens undergoing the bearing tests will be designated in terms of D-load. Such designation indicates the actual load in pounds per linear foot of pipe divided by the inside diameter of the pipe in feet. The pipe shall withstand the required test load before a crack having a width of 0.01 inch measured at close intervals occurs throughout a length of one foot or more. The crack shall be considered 0.01 inch in width when the point of the measuring gauge will, without forcing, penetrate it 1/16 inch at close intervals throughout the specified distance of one foot.

The load shall be applied at a uniform rate not to exceed 2,000 pounds per minute per foot-length of pipe for the first 80 percent of the required load, and then at a uniform rate not to exceed 500 pounds per minute per foot-length of pipe for the remainder of the test.

The test specimens shall be surface-dry when tested.

The length on which the test load is computed shall be determined by measuring the inside length of the barrel of the pipe from the bottom of the socket to the end of the spigot. The length of a beveled pipe shall be the average length of the inside of the barrel of the pipe measured from the bottom of the socket to the end of the spigot.
If the tested specimen of a designated lot passes the test, all of the pipe of that lot shall be considered as complying with the requirements.

If the tested specimen of a designated lot fails to pass the test, then three additional specimens from the same lot shall be selected for testing.

If the three additional specimens pass the requirements of the test, the total number of that lot to be furnished shall be considered as complying with the requirements except that the one previous test specimen failing to meet the test requirements shall be rejected.

If any of the three additional specimens fail to meet the test requirements, the entire lot shall be rejected, or may be down-graded, except those test specimens which met the test requirements during the testing.

The Contractor may test specimens of a rejected lot individually to determine whether they may comply with the requirements for acceptance.

Any D-load bearing strength test shall conform to ASTM C 655, latest edition, if it is not modified by these Specifications.

In addition to D-load bearing strength tests described above, it is required that one short length joint for each internal diameter having a different design D-load requirement shall be bearing loaded to ultimate strength in accordance with ASTM C 655.
2.1.2 REPAIR

Unsound or imperfect concrete shall be removed by chipping. The edges shall be beveled. The area to be repaired shall be kept dry. Loose material and concrete dust remaining after the chipping operation shall be removed by means of an air jet. All concrete repair work shall be trimmed or ground smooth for a neat appearance on the surface.

Epoxy resins previously approved for such use by the Engineer shall be used in the manner prescribed by the Engineer. The prepared area shall be primed with epoxy resin compound, care being taken to ensure intimate contact with the base material. No other materials used in repair of imperfections or damaged pipe is acceptable and shall be rejected regardless of place and nature of repair. An approved epoxy resin shall be equal to "Thiopoxy 63-Grout" as made by Grace and Company, 62 Whittemore Avenue, Cambridge, Massachusetts (Horm Products).

2.1.3 APPURTENANCES

Joints

Joints for RCP shall be rubber-gasket type. The ends of the pipe shall be so formed that, when the pipes are joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface. Each joint shall contain a solid gasket of neoprene, or other material approved by the Engineer, which shall be the sole element for water tightness of the joint. The joint shall not leak when pulled one inch from normal closure for full circumference. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed two degrees. The rubber gaskets shall conform to the requirements of ASTM C 443. Gaskets shall be stored in a cool place and not exposed to the direct rays of the sun.
2.2 INSTALLATION

2.2.1 HANDLING AND STORAGE

See 2A.2.1.

2.2.2 LAYING AND JOINING

Prior to placing the spigot into the bell of the RCP previously laid, the spigot groove, the rubber gasket and the first two inches of the bell shall be lubricated with a soft, vegetable soap compound.

The gasket, after lubrication, shall be uniformly stretched or relieved when placing it in the spigot groove so that the rubber is distributed uniformly around the circumference.

Before assembling the joint, metal or wooden spacers shall be placed against the inside shoulder of the bell in pipe that is 24 inches in diameter or larger to provide the proper space between abutting ends of the pipe.

After the joint is assembled, a thin metal feeler gauge shall be inserted between the bell and the spigot, and the position of the rubber gasket checked around the complete circumference of the pipe. 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 gasket position again checked. All pipe shall be joined in such a manner that the "T" is in the invert and the ends of the plastic liner match in a continuous straight line. Pipe not laid in this manner shall be removed and relaid.
The installation of the liner plate, including the welding of all joints, shall be done in accordance with the manufacturer's recommendations. Nailing through the plate will not be tolerated. Liner plate shall be installed with locking extensions parallel with the longitudinal axis of the sewer unless otherwise shown on the plans. Liner plate shall be held snugly in place against inner forms by means of light gauge steel wire, light steel banding straps, or other suitable means. If steel banding straps are used, they shall be applied in strap channels provided for this purpose.

Locking extensions (T-shaped) shall be integrally extruded to all lower, terminal, or longitudinal edges of liner plate as applied to concrete pipe. If banding straps are used, a steel rod 1/4 inch in diameter may be inserted in each locking extension along the longitudinal edges of each sheet of liner plate for concrete pipe, or some other approved method for holding the lower edge of the liner plate snugly against the form shall be provided.

Concrete poured against liner plate shall be compacted in a careful manner so as to protect the liner plate and to produce a dense, homogeneous concrete securely anchoring the lock extensions into the concrete. In removing forms, care shall be taken to protect liner plate from damage. Sharp instruments shall not be used to pry forms from lined surfaces. All holes and cut, torn, and seriously abraded areas in the liner plate shall be repaired and limited to patches which can be made with a single weld strip. Parallel, overlapping or adjoining weld strips will not be allowed. Patches made entirely with welding strip shall be fused to the liner plate over the
entire patch, and limited to patches which can be made with a single weld strip. Parallel, overlapping or adjoining weld strips will not be allowed. Larger patches may consist of smooth liner plate applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound liner plate adjoining the damaged area.

The Contractor shall take all necessary measures to prevent damage to installed liner plate from equipment and materials used in or taken through the work. The applied lining shall be free from bubbles due to poor workmanship, and the Contractor shall cut out said bubbles and weld a similar sheet in place of the bubble unless otherwise directed by the Engineer.

Liner plate shall be set flush with the inner edge of the bell or groove end of a pipe section and shall extend to the spigot or tongue end or to approximately three inches beyond the tongue end, depending upon the type of liner plate to be made with the adjoining concrete pipe. Wherever concrete pipe, which are protected with liner plate, join structures not so lined; such as brick structures, concrete pipe cast-in place structures, or clay pipe; the liner plate shall be extended over and around the end of the pipe and back into the structure for not less than four inches. Where a pipe spur not of plastic-lined concrete is installed through lined concrete pipe, the liner plate shall be returned four inches at the surfaces of contact. The seal between the liner plate and the spur shall be made using a method recommended by the manufacturer of the sheet and approved by the engineer.
If the joint space is too wide or the joint space surface too rough to allow satisfactory sealing with this method, the joint space shall be filled with two inches of densely-caulked lead wool or other approved caulking material. Lined concrete pipe may be cured by standard curing methods. Care shall be exercised in handling, transporting, and placing lined pipe to prevent damage to the liner plate. No interior hooks or slings shall be used in lifting pipe. All handling operations shall be done with an exterior sling or with a suitable fork lift. No pipe with damaged lining will be accepted until the damage has been repaired to the satisfaction of the Engineer.

The Contractor shall obtain the services of qualified personnel to weld the liner plate field joints. Pipe joints must be dry before the liner plate joints are made. All mortar and other foreign material shall be removed from liner plate surfaces adjacent to the pipe joint, leaving them clean and dry. No liner plate joints shall be made until the trench has been backfilled and the pipe has been tested for leaks.

Field joints in the liner plate at pipe joints may be either of the following described types:

1. Type P-1 – The joint shall be made with a separate four-inch joint strip and two welding strips. The four-inch strip shall be centered over the joint, secured to the liner plate with an approved method, or other approved means, and welded along each edge to adjacent liner plate with a one-inch weld strip. The width of the space between adjacent line plate sheets shall not exceed two inches. The four-inch joint strip shall lap over each liner plate a maximum of one inch.
2. Type P-2 - The joint shall be made with a plastic strip, without locking extensions integrally extruded with the liner plate and extending approximately three inches beyond the spigot end. A one-inch welding strip is required. The joint strip shall overlay the liner plate a minimum of one inch on the downstream side of the pipe joint. An approved adhesive, or other approved means, shall be used to hold the lap in place during the welding. The joint strip on beveled pipe shall be trimmed to a width, measured from the end of the spigot, of approximately three inches for the entire circumferential length of the liner. Distortion in bending back the strip to expose the pipe joint during the laying and joint mortaring shall be avoided. All welding of joints is to be in strict conformance with liner plate manufacturer's specifications.

3. Type P-4 - The joint shall be made with a three-inch weld strip. The three-inch weld strip shall be centered over the joint and welded in place to the lining in adjacent joints of pipe. The weld strip shall lap over each liner plate a minimum of one inch.

2.3 TESTING

In addition to passing the tests described in Section 2A.2.3, RCP shall also pass liner tests as described below.

After the pipe in installed in the trench, all surfaces covered with liner plate shall be tested with an approved electrical Holiday or flaw detector set at a minimum of 20,000 volts. All welds shall be physically tested by a non-destructive probing method. All patches over nail and form tie holes and repairs to the liner plate shall be done in conformance with the instructions and recommendations of the liner-plate manufacturer.
Each transverse welding strip which extends to a lower edge of the liner plate shall be tested. The welding strips shall extend below the liner plate, providing a table. A ten-pound pull shall be applied normal to the face of the pipe by means of a spring balance. Liner plate adjoining the welding strip shall be held against the concrete during application of the force. The ten-pound pull shall be maintained if a weld failure develops until no further separation occurs. Defective welds shall be re-tested after repairs have been made. Tabs shall be trimmed away neatly after the weld strip has passed inspection. The Contractor shall provide all equipment required to test liner plate in the manner recommended by the manufacturer and as described above. The Contractor shall also provide personnel qualified to perform the testing. Testing shall be performed in the presence of the Contracting Agency.

d. POLYVINYL CHLORIDE (PVC) PIPE

2.1 MANUFACTURE

Except as modified herein, all materials, manufacture and testing for PVC gravity sewer pipe shall be in accordance with ASTM D 3034.

2.1.1 QUALITY OF PIPE

Materials

Gravity PVC pipe shall meet the extra-strength minimum of SDR-35 of the requirements of ASTM D 3034, be of clean, virgin PVC, and have a cell classification of 12454-B, 12454-C, or 13364-B meeting the requirement of ASTM D 3034 as defined in ASTM D 1784. Rubber gaskets shall conform with the low-head requirements of ASTM F 477.
Dimensions and Tolerances

Standard pipe lengths shall be 12.5 feet. Random lengths of not more than 15 percent of the total footage may be shipped. The requirements for pipe diameter and wall thickness are set forth in ASTM D 3034. The maximum allowable ordinate as measured from the concave side of the pipe shall not exceed 1/16 inch per foot of length.

Imperfections

Any imperfections which, in the opinion of the Engineer, may adversely affect the performance of the pipe or joints shall be cause for rejection of PVC pipe.

Testing

PVC gravity pipe shall be tested in accordance with ASTM D 3034. The minimum pipe stiffness at five percent deflection shall be 46 for all sizes when tested in accordance with ASTM D 2412.

In addition to the tests at the manufacturer's plant, the Engineer may require that tests be performed on pipe specimens selected at random at the point of delivery or at the job site. The Engineer shall bear the costs of such tests, which shall be in accordance with ASTM D 2412 and D 2444.

2.1.2 REPAIR

There will be no provisions for repair of PVC.

2.1.3 APPURTEINANCES

Joints for PVC gravity pipe shall be made with flexible elastomeric seals (gaskets) in accordance with ASTM D 3212. All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made. All surfaces of the joint upon which the gasket may bear shall be smooth and free of any imperfections which could adversely affect sealability.
Fittings and stoppers shall meet the testing requirements for PVC pipe. Joints shall be capable of passing all tests specified in ASTM D 3212.

2.2 INSTALLATION

PVC pipe shall be installed in accordance with ASTM 2321 except as modified by the Pima County Wastewater Management Standard Details or these specifications.

2.2.1 HANDLING AND STORAGE

PVC pipe shall be delivered to the job site from the factory and stored at the job site in palletized units less than 40 inches high. Care shall be taken during the transportation of the pipe to insure that the tie-down methods do not damage or deflect the pipe.

PVC pipe stored at the job site for a period of three months or more shall be covered with an opaque material to protect it from the sun's rays. Air circulation shall be provided under the covering. PVC pipe shall not be removed from the pallet or laid out along the ditch more than 24 hours prior to being placed in the bedding.

2.2.2 LAYING AND JOINING

In addition to the requirements for pipe installation specified in these specifications, three additional qualifications shall pertain to gravity PVC pipe.

1. Water jetting will not be permitted in the pipe zone.

2. The trench shall not be wheel loaded until three feet of cover is placed over the top of the pipe.

3. A clamp gasket or approved equivalent method shall be provided at manhole entry or connection to reduce infiltration and exfiltration.
2.3 TESTING

In addition to passing the tests described in Section 2A.2.3, PVC pipe shall also pass deflection tests as described below.

Prior to leaving the job storage area, the pipe may, at the option of the Engineer, be subjected to a deflection test using a mandrel with an outside diameter equal to 98 percent of the internal diameter of the pipe. The mandrel shall pass through the pipe without obstruction.

Prior to final acceptance of the project, but not less than seven days after compaction has been completed, the PVC pipe shall be tested for vertical deflection using a mandrel. Deflections exceeding five percent shall be cause for rejection of the pipe.

C. PRESSURE PIPE MATERIALS

a. POLYVINYL CHLORIDE (PVC) PIPE

2.1 MANUFACTURE

Except as modified herein, all materials, manufacture and testing for PVC pressure sewer pipe shall be in accordance with ASTM D 1784.

2.1.1 QUALITY OF PIPE

Material

Forcemain PVC pipe and fittings shall be made from clean, virgin, approved cell classification 12454 A PVC compound as defined in ASTM D 1784. Rubber gaskets shall comply with the high head requirements of ASTM F 477.

Dimensions and Tolerances

The pipe shall be at least 160 psi with a SDR of 26 or less. If 200 psi pipe is specified, it shall have an SDR of 21 or less. PVC pipe shall not be out of straightness by more than 1/16 inch per foot of length. The standard laying length for PVC forcemain pipe is 20 feet.
Imperfections

Any imperfections which, in the opinion of the Engineer, may adversely affect the performance of the pipe or joints shall be cause for rejection.

Testing

PVC forcemain pipe shall be tested in accordance with ASTM D 2241. Tests shall be made on each run of unit of pipe extrusion. The forcemain pipe shall have a minimum stiffness at five percent deflection of 135 for 160-psi pipe and of 255 for 200-psi pipe when tested in accordance with ASTM D 2412.

In addition to the tests at the manufacturer's plant, the Engineer may require that tests be performed on pipe specimens selected at random at the point of delivery or at the job site. The Contractor shall bear the costs of such tests, which shall be in accordance with ASTM D 2412 and D 2444.

2.1.2 REPAIR

There will be no provisions for repair of PVC.

2.1.3 APPURTEANCES

Joints shall be made with flexible elastomeric seal (gaskets) in accordance with ASTM D 3212.

Fittings and stoppers shall meet the testing requirements for the PVC pipe.

Joints shall be capable of passing all tests specified in ASTM D 3212.
2.2 INSTALLATION

2.2.1 HANDLING AND STORAGE

PVC pipe shall be delivered to the job site from the factory and stored at the job site in palletized units less than 40 inches high. Care shall be taken during the transportation of the pipe to insure that the tie-down methods do not damage or deflect the pipe.

PVC pipe stored at the job site shall be covered with an opaque material to protect it from the sun's rays. Air circulation shall be provided under the covering. PVC pipe shall not be removed from the pallet or laid out along the ditch until the bedding material is in place and ready to receive pipe.

2.2.2 LAYING AND JOINING

1. Water jetting will not be permitted in the pipe zone when PVC pipe is used.

2. An approved water stop shall be used at all manholes.

2.3 TESTING

PVC pressure pipe shall be tested as described in Section 2A.2.3.
3. PIPELINES

3.1 HOUSE CONNECTION SEWERS

3.1.1 EARTHWORK

The house connection sewer (HCS) is the branch laid from the main-line sewer to the right-of-way/easement line. The earthwork shall conform to all of the requirements of Section 1, except that the trenches shall be no wider than 30 inches. The trench shall be aligned no less than 90° from the downstream centerline of the main sewer, and shall be no deeper than necessary. Lateral trenches shall only be open on one side of the street at any time. Only six inches of shading shall be required above the pipe, but the pipe shall be at least four feet deep at the property line.

3.1.2 PIPE AND CONNECTIONS

Extra-strength VCP, DIP, or PVC pipe conforming to Section 2 shall be used for all house connections. Flexible compression joints shall be used to join bell and spigot-type pipe. The minimum inside diameter shall be four inches.

Connection to the sewer main shall be made by inserting the spigot end of either a straight section or an 1/8 bend of the house connection into a tee or wye of the sewer main. The tee or wye shall be oriented so that it is tilted at 45° from the horizontal. When connecting to an existing main, or when approved by the Engineer, an epoxy-joined saddle of compatible material with a hole tapped by a machine can be used. The saddle shall not extend beyond the inner surface of the main pipe. No more than one saddle shall be used per laying length, and no
saddle shall be placed within five feet of a structure or another saddle. An inspection clean out wye shall be installed immediately outside the saddle.

The upper end of an unconnected HCS shall be plugged with an approved plug that will mate with the branch joint. This plug will withstand the leakage test and will not damage the pipe when removed. The end shall be marked with a standard-size solid brick attached to the end with a wire. A curb under which any HCS passes shall be engraved with the marking "HCS" directly over the pipe.

Connections to a manhole shall conform to the requirements of Section 4 and the manhole standard details. Such connections shall be allowed only when approved by the Engineer. If a manhole is located at an upstream terminal end in a cul-de-sac where there is no feasibility for future expansion, a maximum of three house connections may be installed into the manhole.

3.1.3 DESIGN

The standard HCS is shown in the Pima County Wastewater Management Department Standard Details.

3.1.4 RECONSTRUCTION

If it is necessary to reconstruct an existing HCS, the owner thereof shall be notified at least 48 hours in advance, and the Contractor shall provide alternate service.

The Contractor shall, at his expense, reconstruct with mechanical compression couplings any HCS, whether new or existing, that is damaged during construction.
3.2 UTILITY CROSSINGS AND PROTECTION

3.2.1 LOCATING, PROTECTING AND SUPPORTING

Existing utilities shall be located and protected and, if necessary, supported, relocated, or replaced. A minimum of two working days prior to commencing the construction, the Contractor shall, using the services of the Blue Stake Center (792-2211), request the applicable utility companies to mark or otherwise indicate the location of their utilities. The Department does not guarantee the accuracy or completeness of information on the location of the utilities. The Contractor shall perform exploratory excavation in advance of trenching to locate all existing utilities.

The Contractor shall not interrupt the service function nor disturb the supporting base of any utility without authority of the owner thereof and the approval of the Engineer. This requirement applies to both above and below ground, and to both public and private facilities including sewer, water, gas, power transmission and distribution, telephone and cable television lines, traffic control facilities, and drainage facilities. The Contractor shall immediately notify the Engineer if any utility is omitted from or incorrectly identified on the plans or not properly marked.

The Contractor shall provide, install, and maintain shoring, if necessary, to maintain the integrity of adjacent or crossed utility facilities. It may be necessary to use a reinforced concrete beam or a concrete support wall to prevent settlement of the utility line after construction.
3.2.2 RELOCATING AND REPLACING

Where a utility is found to interfere with the work, the Contractor or the owner of the utility shall remove the utility and, after passage, reconstruct it with new materials of the same size, type, and quality as that removed. The Contractor, or utility owner, shall take special care to compact under and around the utility to ensure that no voids are left. Temporary service shall be provided during construction, and reconstruction shall be in accordance with applicable specifications. When the plans or specifications call for relocation, and the utilities are correctly located, the costs of relocation shall be included in the bid. When relocation is made for the convenience of the Contractor, all arrangements shall be made and all costs borne by the Contractor.

The Contractor shall not be entitled to damages or additional payment for delays attributable to utility relocations or alterations. If the utilities were not shown, or were incorrectly shown on the plans, the negotiated costs shall be incorporated in a change order.

3.2.3 ABANDONMENT OF SEWER LINES

The Contractor shall cut abandoned lines as shown on the plans and plug both ends with a wall of concrete, or brick and mortar. When conduits that have been or are to be abandoned are found to interfere with construction, the interfering portion shall be removed and the remaining portion sealed.
3.2.4 SEPARATION OF SEWER AND WATER

The purpose of this specification is to insure that no sewage will find its way to any potable supply. A sewer line shall not encroach into the rectangular volume defined as 18 inches above, six inches below, and two feet either side of the outer edge of a potable water line.

If the sewer line and water line are in the same trench, or if the sewer line encroaches into the volume defined as two feet below the bottom of the water pipe, six feet either side of the outer edge of the water pipe and any location above the water line, the sewer pipe shall be made water-tight by using DIP.

Whenever the sewer line is above the water line, the former shall be supported to prevent settling. Whenever a sewer line and water line cross, the joints of the sewer pipe shall be equidistant from the water pipe and as far as possible from the joints of the water pipe.

3.3 CASTINGS

3.3.1 WHEN USED

Casings or DIP shall be used in seven situations as specified herein:

1. Shallow pipes.
2. Heavy loads.
3. Proximity to water lines (3.2.4).
4. Proximity to potential flood water.
5. Jacking and boring (1.7).
7. Flow velocities will exceed ten feet per second (10 FPS).
3.3.2 STEEL CASING

Steel casing shall be used whenever the pipe will be subjected to extraordinarily large loads and in jacking operations (Section 1.7). The casing shall not be less than 3/8 inch thick, or as shown on the plans. The steel shall have a minimum yield strength greater than 35,000 pounds per square inch, and the joints shall be continuous circumferential welds that are watertight. Any section showing signs of failure shall be replaced.

The carrier pipe shall be installed by pushing the pipe into the casing on skids. These metal or redwood skids shall relieve the pipe bells from all loading, and shall brace the pipe so that it will not shift or float during backfill. The carrier pipe shall pass the leakage test prior to backfill.

The void space between the casing and the carrier pipe shall be filled with sand or concrete using a method approved by the Engineer. If sand is used, the Engineer may require that the carrier pipe be laid in gravel bedding.

3.4 TRAFFIC AND ACCESS

3.4.1 GENERAL

All traffic routing and detour operations shall receive prior approval from the agency with jurisdiction over the right-of-way.

3.4.2 SIGNING

Temporary traffic control devices used to guide traffic through construction areas include cones to channelize traffic, portable barricades for warning, vertical-panel channelizing devices to divert traffic, and lighting devices for use between sunrise and sunset.
Advanced warning devices used to alert the motorist of an obstruction in the roadway include diamond-shaped signs, flags, and flasher-type, high-level warning devices mounted eight feet above the roadway.

The Contractor shall maintain all existing "stop," and "yield," and "street name" signs in an erect and clean condition and in full view. If the signs interfere with the construction, they shall be temporarily relocated away from the construction but still in full view of the intended traffic. The Contractor shall reset the sign at the permanent location.

3.4.3 CONTROL

The Contractor shall provide for the safe routing of traffic around the construction area.

1. If the traffic is channelized within the street that contains the construction, cones and barricades shall be used to control the traffic.

2. If the traffic is temporarily routed along a different street, the Contractor shall maintain point control with uniformed off-duty police officers with flashing warning lights.

3. If a temporary traffic lane is necessary, it shall be constructed to a minimum width of 12 feet.

Two lanes should be maintained whenever possible, and shall be maintained at all times on major streets. All lanes on major streets shall be kept open to traffic from 7:00 to 9:00 a.m. and from 4:00 to 6:00 p.m. If only one lane is open, flagmen shall be used at each end of the reach. The Contractor shall conform to all requirements set forth in the "Traffic Control Manual for Highway Construction and
Maintenance" and, if working within the City of Tucson, to the City of Tucson "Street Barricading and Channelization Manual for Temporary Traffic Control."

Safe pedestrian zones at least four feet wide, public transportation stops, and pedestrian crossings at intervals not exceeding 300 feet shall be maintained.

3.4.4 ACCESS

Access to hospitals, fire hydrants, churches, schools, parking lots, police and fire stations, and commercial and industrial establishments shall be continuous and unobstructed. The Contractor shall cooperate with mail and garbage service, and maintain emergency vehicle access at all times. Vehicular access to residential driveways shall be maintained to the property line except when construction activities preclude such access. All occupants whose access will be limited shall be given written notice thereof at least 48 hours in advance.

The maximum reach of a residential street that may be closed is the greater of 600 feet and the distance between manholes. The Contractor shall notify the appropriate police, fire, traffic, engineering, and public transportation departments a minimum of 48 hours in advance of closing, partially closing, or of reopening any street or alley.
3.5 PRESSURE LINES

3.5.1 PRESSURE MAINS

Pressure mains shall meet the requirements of Section 2C. Earthwork shall conform to the requirements set forth in Section 1. The requirements for velocity, air-release valves, waterline separation, and testing shall be those set forth in Chapter 5, Section B-5 of Bulletin 11 (ADHS).

Changes in direction are allowed if thrust blocks consisting of Class B concrete are used. For four and six-inch pipe, the concrete must bear against at least three square feet of undisturbed soil. Standard pressure main construction should conform to the appropriate standard details.

3.5.2 PUMPS AND PUMP STATIONS

Pumps and pump stations shall conform to the requirements set forth in Chapter 5, Section B, Subsections 1 through 4 of ADHS Engineering Bulletin 11.

The standard pump station should conform to the Pima County Wastewater Management Department Standard Details.
4. MANHOLES

4.1 DESIGN AND CONSTRUCTION OF MANHOLES

4.1.1 GENERAL

Except where otherwise specified, all manholes shall be precast reinforced concrete conforming to ASTM C 478. Particular attention shall be given to the requirements for reinforcement specified for the various manhole sections in ASTM C 478. A homogeneous concrete mixture containing at least 564 pounds of Portland cement per cubic yard, and cured according to and meeting the physical requirements of ASTM C 478, shall be used for each manhole section. The minimum compressive strength for all sections shall be 3000 psi.

Brick Manholes

A brick manhole may be used in lieu of a precast concrete manhole.

Brick shall be whole, sound, and hard-burned and shall give a clear ringing sound when struck together. The brick shall conform, except for dimensional tolerances, to the requirements of ASTM C 32, Grade MS. The typical brick size is 2-1/4 by 3-5/8 by 7-5/8 inches.

Brickwork shall not be laid upon a concrete foundation less than 24 hours after such foundation has been poured. No brick work shall be laid in water, nor, except as prescribed for curing, shall water be allowed to stand or run on any brickwork until the mortar has thoroughly set. Where new work is joined to existing unfinished work, the contact surfaces of the latter shall be thoroughly cleaned and moistened.
Bricks shall be thoroughly moistened prior to placing and shall be laid in full cement mortar beds. The horizontal cross section of the manhole shall be circular unless otherwise called for on the plans or standard details. An oval or egg-shaped section will not be permitted. A double row-lock course of brick in the manhole wall shall be arched over the top half of the circumference of all inlet and outlet pipes. The brick manholes shall be plastered outside with 1/2 inch of cement mortar as shown on the Pima County Wastewater Management Department Standard Details. Inside the brick wall shall be neatly pointed. The plaster coat shall be cured with a liquid membrane-forming compound immediately after plaster has been placed and finished.

4.1.2 MANHOLE BASES

An unreinforced manhole base can be used for sewer lines equal to or less than 21 inches in diameter. The reinforced base shall be used for sewer lines greater than 21 inches in diameter and can be used for lines up to 36 inches.

The manhole base shall be a circular slab of Class "A" concrete poured against undisturbed soil or approved bedding. The base, including the flow channel and connections to pipe and barrel section, shall be made in one monolithic pour.

Forms shall be checked and approved for accuracy of dimension and relative smoothness prior to pouring the base. The base shall be shaped with a wood float and receive a hand, steel-trowel finish prior to concrete setting.
If additional mortar is needed after the initial set, the surface to receive the mortar shall be primed and the mortar mixed with an approved adhesive in order to secure as chip-proof a surface as possible. The base shall be set a minimum of 72 hours before the manhole construction is continued.

The bench of the base shall be brush or broom-finished, and shall slope toward the channels at 1 to 2 percent grade. The bench elevation shall be higher than the highest pipe crown in the manhole.

4.1.3 INVERTS

Invert channels shall be troweled to a smooth, dense surface and a semi-circular shape conforming to the inside of adjacent sewer sections. The invert channel shall be formed of concrete, using a template if necessary. It may also be half-tile laid in concrete; or it may be constructed by laying a full section of sewer pipe through the manhole and cutting out the top half after the surrounding concrete has hardened.

A cut-out shall take place, under the inspection of the Engineer, by using a saw-cutter to remove the top portion of the pipe. Care shall be taken to prevent cuttings from entering the sewer, and the Engineer may require balling of the line if an excessive amount of cuttings have fallen into the pipe. After a cut-out, the edges of the pipe shall be filled and smoothed with mortar.

4.1.4 PIPE CONNECTIONS

Where designated as a provision for future lateral extensions, block-outs or, if approved, stub-outs shall be built into the manhole. Flow channels shall be formed in the base for each block or stub-out. Stub-outs shall be plugged with an approved water-tight stopper.
Stub-outs are made by extending a section of pipe with the bell flush with the outside of the manhole base. The pipe shall be sealed with an approved, prefabricated plug or cap.

4.1.5 BARREL AND CONE SECTIONS

Barrel and cone sections of various heights conforming to ASTM C 478 and the Pima County Wastewater Management Department Standard Details shall be used in order to bring the top of the manhole to the designated elevation.

The minimum wall thickness of any section is 1/12 the inside diameter of the barrel or the largest cone diameter. The wall thickness shall be not less than described by design by more than five percent or 3/16 inch, whichever is greater. The variations in laying lengths of two opposite sides of manhole sections shall be not more than 5/8 inch. The underrun in length of a section of manhole base, riser, or conical top shall be not more than 1/4 inch per foot of length with a maximum of 1/2 inch in any one section.

Manhole sections shall be subject to rejection because of any of the following:

1. Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
2. Defects that indicate imperfect proportioning, mixing, and molding.
3. Surface defects indicating honeycombed or open texture.
4. Damaged or cracked ends, where such damage would prevent making a satisfactory joint.
5. Any continuous crack having a surface width of 0.01 inch or more and extending for a length of 12 inches or more, regardless of position in the section wall.

The joints between sections of the manhole shall be formed with male and female ends to make a continuous and uniform manhole. The joint surfaces shall be thoroughly cleaned prior to sealing.

The manhole sections shall be sealed to each other with a pre-formed flexible gasket conforming to the following requirements:


2. The plastic sealing compound shall be packaged in extruded preformed rope-like shape of proper size to completely fill the joint when fully compressed. The material shall be protected by a suitable, removable wrapper. The sealing compound shall be impermeable to water, have high immediate bonding strength to the primed concrete surface and shall maintain permanent plasticity, resistance to water, acids, and alkalies.

3. All surfaces of the tongue and groove joint of the manhole barrel shall be clean prior to the installation of the sealing compound. The application of the sealing compound shall be accomplished in strict conformance with the manufacturer's instructions as to the method of application, quantity of material, the grade of the materials and the application temperatures.
4. All lifting holes shall be sealed with the plastic sealing compound.

4.1.6 DROP MANHOLES

The drop manhole shall be a standard precast manhole with the modifications as specified in the Pima County Wastewater Management Department Standard Details. The inside diameter of the drop inlet pipe shall be the same diameter as the intercepted sewer. The drop connection shall be enclosed in concrete. If a pour separate from the base is made, Class "B" concrete can be used.

4.1.7 FLAT TOP MANHOLES

Flat top manholes shall conform to the appropriate Pima County Wastewater Management Department Standard Details.

4.1.8 FRAMES AND COVERS

Frames and covers shall be made in accordance with the Pima County Wastewater Management Department Standard Details, shall conform to ASTM A 48 and shall be designed to withstand H-20 loading.

The bearing surfaces of the frames and covers shall be machine-finished, and the cover shall seat firmly onto the frame so that there shall be no movement of the cover under traffic with the cover in any position on the ring. The tops of the covers and frames shall be flush, and there shall be 1/8 inch clearance all around between frame and cover.

The top surface of each cover shall be cast with a studded pattern, including lettering. The letter and studs shall be raised 5/16 inch. The letter shall not be less than 1-1/2 inches high.
Each cover except waterproof covers shall be provided with not less than four ventilating holes, each of which is 3/4 inch in diameter unless otherwise specified on the plans.

The elevations at which frames and covers are to be set shall conform to the requirement set forth on the Plans, but in all cases shall be governed by the Engineer in the field. Where the cover is in existing pavement or in the traveled way of the existing road shoulder, it is to be placed flush with the existing surface. Where the structure is outside the limits of the traveled shoulder or pavement, it should be placed 1/10 foot or more above the existing ground surface. Manhole frames shall be set at the required grade and shall be securely attached to the top precast manhole shaft unit with a grout bed and filled as shown on the Pima County Wastewater Management Department Standard Details. After the frames are securely set in the place provided herein, covers shall be installed and all necessary cleaning and scraping of foreign materials from the frames and covers shall be accomplished to ensure a fine, satisfactory fit.

The castings shall be dipped in asphalt at not less than 200°F after they have been thoroughly cleaned.

Castings

All castings shall be true to pattern in form and dimension and free from pouring faults, sponginess, cracks, blowholes, or other defects in locations affecting their strength and value for the service intended. Castings shall be filleted boldly at angles, and the risers shall be sharp and true. Before the castings are removed from the foundry, they shall be thoroughly cleaned and the parting lines, gates
and risers ground flush. No plugging or other stopping of holes will be allowed. The castings shall be thoroughly cleaned of all lumps and subject to a careful hammer test.

Test coupons shall be cast separately of the castings using a mold as described in ASTM A 48. Two test coupons are required for each melt poured. Additional coupons shall be cast for use as replacements or in case a retest is required. The Engineer may discard or replace specimens which show obvious lack of continuity of metal or if the machining is defective.

The manufacturer shall machine the tension specimens to the dimension specified for specimen "B" of ASTM A 48. When approved by the Engineer, transverse tests may be made in lieu of tensile tests.

4.1.9 STEPS

Steps for manholes shall be polypropylene plastic-coated Number 3 deformed bars conforming to the requirements of ASTM C 478. Steps for precast concrete manholes and for brick manholes shall conform to the Pima County Wastewater Management Department Standard Details. Steps shall be placed at equal intervals of 12 to 15 inches. The lower step shall not be more than 18 inches from the top of the manhole bench, and the upper step shall not be more than 24 inches below the top of the frame. Steps shall be located above a solid bench.

4.2 TESTING MANHOLES

The Engineer may require a test be conducted to determine that the manhole is watertight. This test shall be carried out by filling the manhole with water to an elevation one foot above the beginning of the cone section, but to a maximum depth of 20 feet. The water shall stand
in the manhole for a minimum of one hour to allow the concrete to reach maximum absorption. After one hour, the Contractor shall refill the manhole to the original depth, and the drop in the water surface shall be recorded after a period of two minutes for each foot of depth. The maximum allowable drop in water surface for the period of testing shall be 1/2 inch for each 15 minutes of testing.

Repairs shall be made as directed by the Engineer whenever leakage exceeds the test limits.

4.3 EXISTING FACILITIES

4.3.1 RAISING AND LOWERING EXISTING MANHOLES

All raising and lowering of existing manholes shall be done in accordance with the applicable Pima County Wastewater Management Department Standard Details.

4.3.2 CONNECTION TO EXISTING MANHOLES

The following procedures shall be followed when connecting a new sewer line to an existing manhole that has no stub-out or block-out. Concrete core manhole riser to accommodate new pipe. After the new main is laid, the opening through the wall around the new main shall be sealed off with material compatible with existing manhole wall components.

The existing bench shall be broken out to a minimum depth of one inch and thoroughly cleaned. The new bench and channel shall be formed from mortar of Class "A" concrete with an epoxy additive used to assure adequate bonding to existing bench. All surfaces shall be steel-troweled to a smooth, dense surface.
4.4 **CONCRETE**

Portland cement concrete shall be composed of Portland cement, fine and coarse aggregates, water and, if provided for or allowed, certain admixtures.

4.4.1 **MATERIALS**

**Cement**

Portland cement shall conform to the "Standard Specifications for Portland Cement," ASTM C 150, and subsequent revisions or addendums, and shall be Type II. The concrete manufacturer or the Contractor shall present the Engineer, upon written request, a certified analysis of the cement.

**Fine and Coarse Aggregates**

Fine and coarse aggregates shall conform to the "Specifications for Concrete Aggregates," ASTM C 33. Master Builders' "Pozzolith 8" or approved equal, in the amount of 1/4-pound per sack of cement, or Johns-Manville "Celite," or approved equal, in the amount of two pounds per sack of cement, may be added (only with the approval of the Engineer) to improve workability of ordinary structural concrete.

**Water**

Water used in mixing concrete shall be clean and free from strong acids, alkalies, oils, salts, organic materials, or other deleterious materials.

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Water

Water used in mixing concrete shall be clean and free from strong acids, alkalis, oils, salts, organic materials, or other deleterious materials.

4.4.2 CLASSES OF CONCRETE

1. The classes and master limits of concrete are shown in the following table:

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Minimum Cement Content - Sacks per Cubic Yard</th>
<th>Maximum Water Content - Gallons per Bag Cement</th>
<th>Minimum Required Strength at 28 Days Compressive (a) (Flexural) (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5-1/2</td>
<td>6-1/2</td>
<td>3,000 (300)</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>7-1/4</td>
<td>2,500 (250)</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>8</td>
<td>2,000 (200)</td>
</tr>
</tbody>
</table>

(a) As tested in accordance with ASTM C 39.
(b) As tested in accordance with ASTM C 293.

2. Class "A" concrete shall be used for all portions of any required reinforced concrete bases for the manholes, the invert, channel and bench portions of all the manhole bases built in accordance with the Pima County Wastewater Management Department Standard Details.

3. Class "B" concrete shall be used where specified on the Contract Plans.

4. Class "C" concrete shall be used where specified on the Contract Plans.

In designing the concrete mix, the following slump values shall be attained:
SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Maximum Slump in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footings and Substructure Walls</td>
<td>3</td>
</tr>
<tr>
<td>Slabs, Beams, Reinforced Walls, Columns and Manhole Bases</td>
<td>4</td>
</tr>
</tbody>
</table>

High Early-Strength Concrete

In order to expedite the construction of certain designated new sewer manholes, the construction sites of which are located in the traveled areas of high-volumed traffic count streets, high early-strength concrete will be used for the construction of the structural portion of the manhole bases. High early-strength concrete will only be utilized for those manholes called out specifically on the Contract Plans or as approved in advance by the Engineer. This, in effect, will allow the placement of the balance of the manhole shaft, cone and the ring and cover segment on the structure portion of the manhole base within 36 hours after the concrete is placed.

To achieve the high early-strength characteristic, Master Builders' "Pozzolith #100 HE" accelerating admixture, or an approved equal, may be added at a rate of 16-32 fluid ounces per 100 pounds of cement (in accordance with the manufacturer's recommendation) to the Ordinary Structural Concrete and/or the Watertight Chemical Resistant Concrete (whichever is required to construct the structural portions of the manholes involved). The exact amount (to be approved by the Engineer) of Pozzolith #100 HE to be added per 100 pounds of cement shall be that amount necessary to obtain adequate strength (compressive) in the concrete to support the balance of the manhole structure and traffic loads within 36 hours of the pour.
Sufficient specimens (cylinders) shall be taken during the pour and tested at the 36-hour mark in order to ascertain that the concrete has reached sufficient strength to handle the dead and live loads. Exact procedures shall be approved by the Engineer in advance.

High early-strength concrete may be utilized by the Contractor for other concrete work on the job, but not without advance written approval from the Engineer.

4.4.3 CONCRETE MIX DESIGN

Unless stated on the Contract Plans or in the Contract's Special Provisions, the concrete mix design shall be the responsibility of the concrete manufacturer or the Contractor. The concrete Manufacturer or Contractor shall furnish the Engineer a certified copy of the design mix.

Concrete Proportions and Consistency

The proportions of aggregate to cement for any concrete shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement with the method of placing employed on the work, but without permitting the materials to segregate or excessive free water to collect on the surface.

To avoid unnecessary or haphazard changes in the consistency, the aggregate shall be obtained from a source which will insure uniform quality, moisture content, and grading, during any single day's operations and the concrete shall be delivered to the work and handled in such a manner that variations in moisture content will not interfere with the steady production of concrete of the specified strength.
Sampling and Testing

The Engineer shall require a reasonable number of tests to be made during the progress of work. At least three specimens shall be made for each test. Test specimens shall be from the first truck load of the day, and not less than one test shall be made for each 25 cubic yards of concrete. Field tests of concrete shall be made in accordance with AASHO Designation T-23-57 and T-119-56.

The age for strength tests shall be 28 days or, where specified, the earliest age at which the concrete is to receive its full working load. Additional tests may be made at earlier ages to obtain advance information on the adequacy of strength development where age-strength relationships have been established for the materials and proportions used.

Sampling, preparation and testing of the concrete will be made by or under the supervision of the Engineer.

4.4.4 MIXING

Transit and Truck Mixing

Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in "Specifications for Ready-Mixed Concrete," ASTM C 94. No water may be added at the job in order to facilitate concrete flows.
Hand Mixing

If it becomes necessary to mix a small portion of concrete by hand, permission shall be obtained, in writing, from the Engineer. If allowed, the total quantity of such batches shall not exceed one-half cubic yard. The materials shall be accurately measured and mixed dry on a wooden platform of well-jointed planks so as to prevent loss of cement. Mixing on the bare ground or on the floors of buildings will not be permitted under any circumstances. The mass shall be thoroughly turned over at least six times, water being added after the third time. The time between mixing and placing shall not be prolonged to the point where initial set occurs.

4.4.5 PLACING

Preparation of Place of Deposit

The place of deposit shall conform to the requirements of the plans and Specifications and be approved by the Engineer before placement of the concrete may begin.

All absorptive surfaces against which concrete is to be placed shall be moistened sufficiently to minimize moisture loss from the freshly-placed concrete.

The trench or excavated area must be free of water, dirt, mud, and debris before the concrete is placed.

Forms

Forms may be either of metal or wood, and shall be built true to shape, line and grade, mortar-tight, and sufficiently rigid to prevent displacement or sagging between supports. No form shall be used which is not clean and in every way suitable. Deformed, broken, or defective forms shall be removed from the job.
Contact surfaces for exposed concrete surfaces shall be of plywood, metal, or non-warping fiberboard. The pieces used shall be as large as the form layout permits. Small pieces shall not be patched together.

For unexposed surfaces and rough work, square-edge lumber may be used for forms. By unexposed surfaces, it is meant any concrete surface not exposed to view on completion of the project.

All formwork shall be provided with adequate cleanout openings to permit inspection and easy cleaning after all reinforcement has been placed.

Form ties shall be such that when the forms are removed, no metal remains within 3/4 inch of the surface of the concrete nor shall there be any holes larger than 7/8 inch in the surface of the concrete. Wire ties will not be permitted.

All external angles of beams, columns, edges of concrete structures and sides of walls shall be given a 3/4 inch chamfer unless otherwise indicated on the Contract Plans.

Floor slabs in the area of their juncture with walls shall be washed free of sawdust, chips, and other debris after wall forms are built and immediately before the concrete placement. Should the formwork confine sawdust, chips, and other loose matter in such a manner that it is impossible to remove them by flushing with water, a vacuum cleaner shall be used for their removal, after which the cleaned surfaces shall be flushed with water.
Before placing concrete, the forms shall be coated with a
non-staining lubricant to prevent adherence of concrete. All forms and
form lumber, once used, shall be thoroughly cleaned and contact
surfaces recoated before being used again.

**Conveying**

Concrete shall be conveyed from the mixer to the place of final
deposit by methods which will prevent the separation or loss of
materials. Equipment for chuting, pumping, and pneumatically conveying
concrete shall be of such size and design as to insure a practically
continuous flow of concrete at the delivery end without the separation
of materials. Chutes and devices for conveying and depositing concrete
shall be so designed and used that the concrete shall be directed
vertically downward when discharged from the chute or conveying device.

**Placing**

No concrete shall be placed without the prior approval and direct
supervision of the Engineer. The Contractor shall notify the Engineer
by written memorandum of his readiness to place concrete in any portion
of the work. These notifications shall be made at such a time in
advance of the pouring operation as the Engineer deems necessary for
him to make final inspection of the preparations at the location of the
proposed concrete placing.

The Contractor shall schedule his pouring in such a manner as to
complete any single day's pour to a construction, contraction, or
expansion joint. No concrete shall be dropped freely into place from a
height greater than three feet. Tremies shall be used for placing
concrete where the drop is in excess of three feet. Concrete shall be
placed in approximately horizontal layers, not to exceed 24 inches in
depth; and the concreting shall be carried on in a continuous operation within the limits of practicability until the placing in the course, section, panel or monolith is completed. Concrete shall be deposited at or near its final position to avoid segregation caused by rehandling or flowing.

In order to preserve the strength and water-tightness of the structures, no joints shall be made except as shown on the Contract Plans or as the Engineer may direct or approve. An approved water stop shall be placed in the top portion of the first pour. It shall be placed vertically in the first pour such that the exposed portion of the stop will become an integral part of the second pour, thereby accomplishing a complete and effective water stop. At construction joints, the concrete in place shall be thoroughly cleaned of laitance, grease, oil, mud, dirt, tar droppings, and other objectionable material; after which the surfaces shall be washed just prior to the succeeding pour. Keyways on vertical joints shall be set to extend into subsequent sections of the construction as shown on the Contract Plans.

Pipes, anchor bolts, steps, casings, and other inserts as shown on the Contract Plans shall be encased in the concrete unless otherwise noted. Dovetail anchors or ties shall be used in conjunction with the slots or inserts for the various materials, as specified under their respective sections, and as may be necessary for the required work.
Concrete in structures shall be placed with the aid of vibrators. The vibration shall be sufficiently intense to cause the concrete to flow or settle readily into place; and to visibly affect the concrete over a radius of at least 18 inches. Vibration shall be supplemented by manual forking or spading adjacent to the forms on exposed faces to secure smooth, dense surfaces. The concrete shall be thoroughly consolidated around reinforcement, pipes, inserts, and other shapes built into the work. Sufficient vibrators shall be on hand at all times to vibrate the concrete as it is placed. No concrete shall be placed until it has been ascertained that all vibrating equipment required is in serviceable condition.

Placement of concrete on slopes shall commence at the bottom of the slope.

No concrete shall be poured during rainstorms, when the base on which it is to be placed is in a wet or frozen condition, at temperatures less than 40° F, or when the temperature is less than 45° F and falling.

No concrete shall be used which has received its initial set (this is considered as 90 minutes after batching). Retempered concrete shall be wasted.

Removal of Forms

Forms shall remain in place a sufficient time to allow the concrete to set properly. Forms may be removed when tests made by the Engineer indicate that 75 percent of the designed strength of the concrete has been obtained or when the concrete has sufficient strength to carry its own weight and the loads upon it with safety. The
Engineer may, when he deems it advisable, order the forms to remain for a longer time; however, his permission to remove the forms shall not relieve the Contractor of responsibility for the proper removal of them.

An exception to the above criteria for form removal will apply in the case of using high early-strength concrete. The forms in that case will be removed within 36 hours after placement, but not without approval of the Engineer.

**Finishing Exposed Concrete**

Cavities produced by form ties and surfaces honeycombed or requiring repairs shall be thoroughly cleaned, saturated with water and carefully filled and pointed up with cement mortar. On all exposed surfaces, fins and projections shall be removed. Joints shall be left smooth by grinding, if necessary; however, it will not be necessary to remove form marks if the joints are smooth. No other concrete finish is required for formed surfaces unless otherwise specified.

Jointing, where indicated or directed, shall be carefully done with a jointing tool as specified. Top edges of walls, copings, walks, slabs, etc., shall be finished with a one-inch radius edger or receive a chamfer as noted on the Contract Plans.

Cement mortar finishing coat, where specified on the Contract Plans, shall consist of cement and fine aggregate in accordance with the Specification; and shall be proportioned in the ratio of one part cement to two parts fine aggregate. Proportioning shall be by volume.

Cement mortar for the repair of imperfect concrete work shall consist of cement and sand mixed in the same proportions as used for the concrete being repaired with only sufficient water to give the
required consistency. For dry-tamping, only enough water shall be used so that the resulting mortar will crumble to the touch after being "balled." Particular care shall be exercised in placing mortar since it will be expected to furnish structural strength, an impermeable water seal, or both. Mortar which has not been used within 30 minutes after mixing shall be wasted.

4.4.6 CURING

Concrete exposed to rain during operations shall be protected to prevent the rain water from coming in contact with it. Sufficient protective covering shall be kept on hand at all times for this purpose.

All concrete surfaces of the water-bearing parts of structures shall be cured for seven days by keeping the surface of the concrete constantly and visibly moist day and night. For unformed surfaces the curing period shall commence the day following the pouring of the concrete. For vertically-formed surfaces the curing period shall start immediately after the removal of the forms and finishing.

The Contractor, at his option, may cure the new concrete by covering the surface with a membrane-curing compound. The compound shall be such that it can be used with safety under properly-controlled conditions. It shall be applied in one coat at a coverage of ten square feet per gallon. The curing compound shall comply with ASTM C 309 and subsequent revisions or addendums, and shall be Type 1 or Type 2.
When a curing compound is used on an unformed concrete surface, application shall commence immediately after finishing operations are completed. In the event application of the compound is delayed, the concrete surface shall be kept continually moist until the compound is applied or the specified period of water curing has elapsed.

When a curing compound is to be used on a formed concrete surface, the surface shall be moistened with a light spray of water and the compound applied as soon as practicable after finishing operations. It is of utmost importance that the concrete be in a thoroughly water-saturated state at the time of application of a curing compound. Spraying of the compound shall not commence until the concrete has been soaked to such an extent that the surface film of moisture disappears and there is an approach to surface dryness. The curing compound shall then be applied. In the event application of the compound is delayed, the specified moistening of the concrete surface shall be continued until the time of application. Special care must be taken to insure ample coverage of edges, corners and rough spots of the formed surface.

4.4.7 REINFORCING STEEL

Reinforcing steel shall be new; free from dirt, oil, paint, mill scale, or rust; and fabricated and shaped in accordance with this specification, and the Contract Plans. All steel shall be shop bent.

Materials

Bar reinforcement shall be deformed billet-steel bars for concrete reinforcement conforming to ASTM A 615 for intermediate grade 40.

Wire reinforcement shall be cold drawn steel wire for concrete reinforcement conforming to the requirements of ASTM A 82, or wire fabric conforming to the requirements of ASTM A 185.
Construction Methods

All reinforcing steel shall be accurately placed and, during the placing of concrete, firmly held in the position shown on the Contract Plans. Distance from the forms shall be maintained by means of stays, blocks, ties, hangers or other approved supports. Approved bar chairs and spacers shall be used in beams and girders. The use of pebbles, pieces of broken stone or brick, metal pipe, or wood blocks will not be permitted. Reinforcement in any member shall be placed, inspected, and approved before any concrete is placed. Reinforcing bars shall be securely wired together in accordance with the recommendations of the Concrete Reinforcing Steel Institute.

Splicing and Lapping

Unless otherwise shown on the Contract Plans, bars in the bottom of beams and girders, and in walls, shall be lapped 36 diameters. Bars near the top of beams and girders shall be lapped 36 diameters. Lapped splices shall be tied with 16-gauge wire.

Sheets of wire fabric or bar-net reinforcement shall be lapped at least one mesh in width.

4.5 MORTAR

All mortar used on this project shall be composed of not less than one-part Portland cement to three-parts sand by volume, with an allowable addition of 1/4 to 1/2 part lime putty.

The cement and sand shall be of the quality and kind specified under "Concrete" except that the sand shall all pass a No. 10 Standard Screen.

The mortar shall be well-mixed and used immediately after mixing and before it has taken initial set. No mortar that has partially hardened shall be retempered or used in any way.