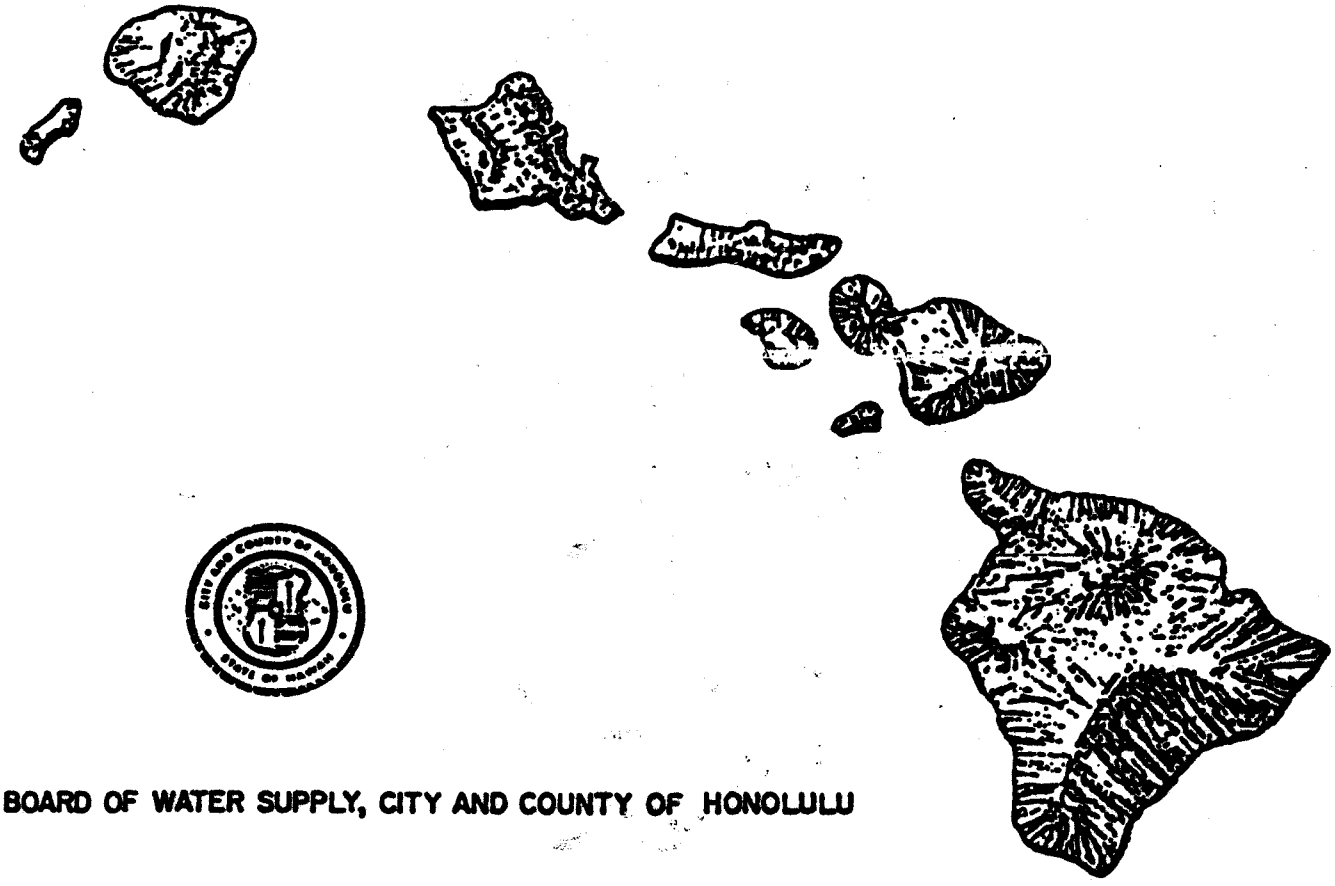
WATER SYSTEM EXTERNAL CORROSION CONTROL STANDARDS



BOARD OF WATER SUPPLY, CITY AND COUNTY OF HONOLULU

1991
VOLUME 3

WATER SYSTEM EXTERNAL CORROSION CONTROL STANDARDS

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CITY AND COUNTY OF HONOLULU

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FOREWORD

SCOPE

This publication shall govern the corrosion control design and construction for the water system facilities under the jurisdiction of the Department of Water Supply.

Any feature of design, materials to be installed, or construction methods to be used for any installation within the Water System External Corrosion Control Standards, but not specifically described herein, shall be of good quality, according to accepted practice, and shall meet with the approval of the Manager.

The Water System External Corrosion Control Standards is Volume 3 of the Water System Standards and subdivided as follows:

- Volume 3
  - Part 1 Soil Evaluation
  - Part 2 External Corrosion Control Requirements
  - Part 3 Pipe Coatings
  - Part 4 Cathodic Protection Design
  - Part 5 Corrosion Control Products
  - Part 6 Corrosion Control Execution
  - Part 7 Testing
  - Part 8 Payment
  - Part 9 Approved Material List
  - Part 10 Corrosion Details

DEFINITIONS

The following definitions are in addition to the ones in Volume 1 of the Water Systems Standards.

- Foreign Owned--Any buried pipe or cable not specifically owned or operated by the BWS.

- Lead, Lead Wire, Joint Bonds, Pipe Connection Wires, Cable--Insulated copper conductor; the same as wire.

- Electrically Continuous Pipeline--A pipeline which has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in the testing section.

- Electrical Isolation--The condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casing, etc.) and the environment as defined in NACE Standard RPO169-83.

REFERENCE STANDARDS

When reference is made to known standard specifications, the most recently adopted and published edition of such specification on the date of the notice to bidders is contemplated, unless otherwise specified.

ABBREVIATIONS

The following abbreviation is in addition to the ones in Volume 1 of the Water System Standards:

- NACE -- National Association of Corrosion Engineers
  P.O. Box 218340
  Houston, Texas 77218
  (713) 492-05351

TABLE OF CONTENTS

SECTION

PART 6 - CORROSION CONTROL EXECUTION

PART 7 - TESTING

PART 8 - PAYMENT

PART 9 - APPROVED MATERIAL LIST

PART 10 - CORROSION DETAILS

Part 1
SOIL EVALUATION

SECTION 1–REQUIREMENTS

1.1 **General:** To determine what corrosion control measures are required for the various pipe alternatives, a soil investigation shall be performed before and/or during the pipeline design.

1.2 **Investigation requirements:** The following table, Table 1, indicates the soil investigation that must be performed for each pipeline project.

Table 1
SOIL INVESTIGATION REQUIREMENTS

PIPE TYPE	SOIL INVESTIGATION
Ductile Iron	1. Soil resistivity at 300-foot increments (pipe depth).
Concrete Cylinder	1. Soil resistivity at 300-foot increments (pipe depth). 2. Soil analyses (pH, chloride, and sulfates) at 1000-foot increments (pipe depth).
Non-Metallic	1. Soil resistivity at 300-foot increments (pipe depth).

1.3 **Soil Corrosion Rating:** The corrosion control methods used for the various pipe alternatives depend on the soil corrosion rating. Table 2 gives the corrosion rating and anticipated corrosion activities based on soil resistivity.

Table 2
CORROSION RATING AND ANTICIPATED CORROSION ACTIVITY

RESISTIVITY (OHM-CM)	CORROSION RATING	ANTICIPATED CORROSION ACTIVITY
0 - 1,000	1	Extremely Corrosive
1,000 - 3,000	2	Very Corrosive
3,001 - 5,000	3	Corrosive
5,001 - 10,000	4	Moderately Corrosive
Over 10,001	5	Mildly Corrosive

1.4 **Soil Analyses:** The corrosion control method used on concrete cylinder pipe depends on the pH, chlorides, and sulfates found in the soil.

1.4.1 **Chlorides:** If chlorides of 300 parts per million (ppm) or higher are found in the area, it shall be given a corrosion rating 1.

1.4.2 **Sulfates:** If water soluble sulfate in soil samples exceeds 2,000 ppm and/or sulfate in water samples exceeds 1,500 ppm, the area shall be given a corrosion rating 1.

1.4.3 **pH:** If soils with a pH of less than 5.0 are found, the area shall be given a corrosion rating 1.

SECTION 2-SOIL RESISTIVITY

2.1 **Definition:** Resistivity is the electrical resistance of a unit volume of a material; the reciprocal of conductivity. Resistivity measurements indicate the relative ability of a medium to carry electrical currents. When a metallic structure is immersed in a conductive medium, the ability of the medium to carry current will influence the magnitude of galvanic and cathodic protection currents.

2.2 **Methods:** The two basic methods of performing soil resistivity shall be either the Wenner 4-Pin method or the Soil Box method. Both tests shall be performed in accordance with ASTM G-57 standard.

2.3 **Recording:** The soil resistivity measurements and their location shall be tabulated and plotted on a graph (semi-log paper) for the Manager to review. Typical data sheets and a typical graph set-up are shown in Figures 1 through 3.

SECTION 3–SOIL ANALYSES

3.1 **Laboratory Evaluation:** The soil samples shall be tested by an approved soils testing laboratory for pH, chlorides, and sulfates using the water soluble method. The preparation of the soil sample for corrosion evaluation shall be in accordance to ASA 9 10-2. The measurements shall be in accordance to EPA SW9045 (pH) and EPA 300 (chloride and sulfate).

3.2 **Recording:** The test results shall be tabulated for the Manager to review. A typical data sheet is shown in Figure 4.

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

DEPTH TO BOTTOM OF PIPE:_____ BY_____

SOIL RESISTIVITY

TEST NO.	SAMPLE DEPTH	LOCATION	PIN SPACING (FT) (1)	RESISTANCE (OHM) (2)	RESISTIVITY (OHM-CM) 1 x 2 x 191.5	CORROSION RATING

Resistivity Range (ohm-cm)	Corrosion Rating
0-1000	1
1,001-3,000	2
3,001-5,000	3
5,001-10,000	4
Over10,001	5

Figure I
Wenner 4-Pin Method

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

DEPTH TO BOTTOM OF PIPE:_____ BY_____

SOIL RESISTIVITY

TEST NO.	LOCATION	SAMPLE DEPTH	RESISTIVITY (OHM-CM)	CORROSION RATING

RESISTIVITY RANGE (OHM - CM)	CORROSION RATING
0 - 1000	1
1001 - 3000	2
3001 - 5000	3
5000 - 10,000	4
over 10,000	5

Figure 2
Soil Box Method

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

DEPTH TO BOTTOM OF PIPE:_____ BY_____

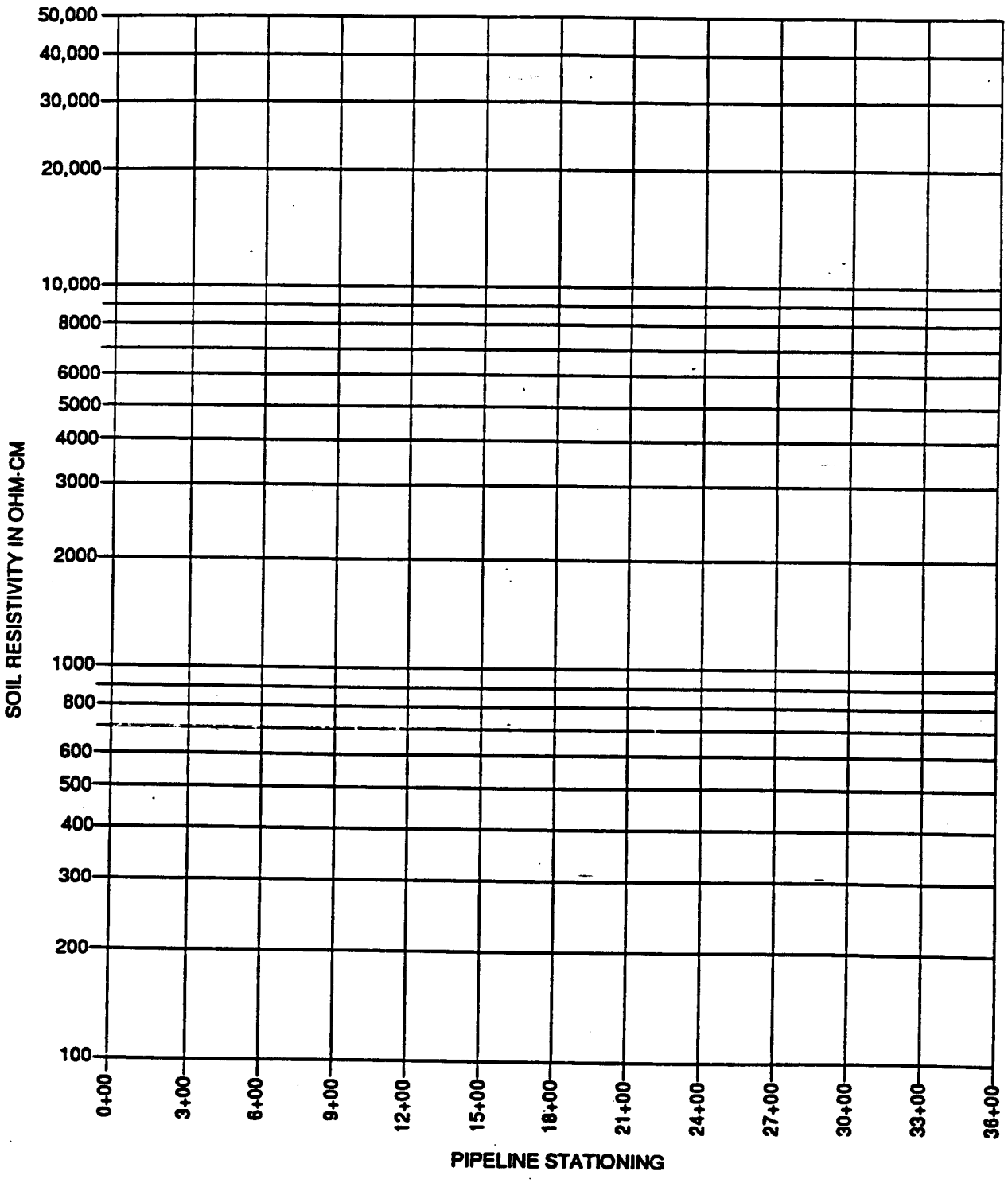


Figure 3
Soil Resistivity

LABORATORY NAME:_____

PIPELINE LOCATION: _____SHEET____OF_____

PIPE SIZE:_____DATE:_____

DEPTH TO BOTTOM OF PIPE:_____BY_____

SOIL ANALYSES

TEST NO.	SAMPLE DEPTH (FT.)	LOCATION	pH	CHLORIDES ppm	SULFATES ppm	RATING 1 YES NO

Corrosion Rating 1 Equals:

pH = <5.0
Chloride = 300 ppm or greater
Sulfates = >2000 ppm (soil sample)
>1500 ppm (water sample)

Figure 4

Part 2
EXTERNAL CORROSION CONTROL REQUIREMENTS

SECTION 1–REQUIREMENTS

1.1 **General:** Unless otherwise approved, external corrosion control is required for each type of pipe used within the water system. The type of external corrosion control required depends on the pipe type and the corrosion rating in which the pipe will be installed. The corrosion rating is shown in Part 1, Table 2, of this document.

1.2 **Corrosion Control Requirements:** The external corrosion control requirements, according to pipe type and corrosion rating are shown in Table 3. The corrosion control products and execution are covered in this document. The connection between the various pipe materials and/or metallic casings can cause galvanic corrosion. Therefore, the requirements for electrical isolation is shown in Table 4.

Table 3
EXTERIOR CORROSION CONTROL REQUIREMENTS

Pipe Material	Soil Resistivity (ohm-cm)/Soil Rating Category			
	0-1,000 Rating 1	1,000-3,000 Rating 2	3,000-5,000 Rating 3	5,000 and above Ratings 4 and 5
Ductile Iron Pipe, Fittings and Valves, 16" and larger AWWA C151	1. Bonded coating 2. Joint bonding 3. Test stations 4. Cathodic protection 5. Electrical Isolation 6. High resistant cushion material	1. Bonded coating 2. Joint bonding 3. Test stations 4. Cathodic protection 5. Electrical Isolation 6. High resistant cushion material	1. Double Polyethylene Encasement 2. Joint bonding 3. Test stations 4. Electrical Isolation 5. High resistant cushion material	1. Double Polyethylene Encasement 2. Joint bonding 3. Test stations 4. Electrical Isolation 5. High resistant cushion material
Ductile Iron Pipe, Fittings and Valves Smaller than 16" AWWA C151	1. Bonded coating 2. Joint bonding 3. Test stations 4. Cathodic protection 5. Electrical Isolation 5. High resistant cushion material	1. Double Polyethylene Encasement 2. Electrical Isolation 3. High resistant cushion material	1. Double Polyethylene Encasement 2. Electrical Isolation 3. High resistant cushion material	1. Double Polyethylene Encasement 2. Electrical Isolation 3. High resistant cushion material
Concrete Cylinder Pipe and Fittings (All Sizes) AWWA C303	1. Type II modified cement 2. Coal tar epoxy coating 3. Joint bonding 4. Test stations 5. Cathodic protection 6. Electrical Isolation 7. High resistant cushion material	1. Type II cement 2. Joint bonding 3. Test stations 4. Cathodic protection 5. Electrical Isolation 6. High resistant cushion material	1. Type II cement 2. Joint bonding 3. Test stations 4. Electrical Isolation 5. High resistant cushion material	1. Type II cement 2. Joint bonding 3. Test stations 4. Electrical Isolation 5. High resistant cushion material
Polyvinyl Chloride (PVC) Pipes (All Sizes) and PVC Fittings AWWA C900 AWWA C905	1. High resistant cushion material 2. Do not connect tracer wire to metallic fittings 3. See Metallic fittings	1. High resistant cushion material 2. Do not connect tracer wire to metallic fittings 3. See Metallic fittings	1. High resistant cushion material 2. Do not connect tracer wire to metallic fittings 3. See Metallic fittings	1. High resistant cushion material 2. Do not connect tracer wire to metallic fittings 3. See Metallic fittings

Table 3
(continued)

Pipe Material	Soil Resistivity, ohm-cm 0-1,000 Rating 1	1,000-3,000 Rating 2	3,000-5,000 Rating 3	5,000 and above Ratings 4 and 5
Copper Pipe	1. Insulate from ferrous metal piping 2. Install galvanic anode.	1. Insulate from ferrous metal piping	1. Insulate from ferrous metal piping	1. Insulate from ferrous metal piping
Metallic Fittings and Valves for AWWA C900 PVC Pipe	1. Supply with fusion bonded epoxy coating 2. Cathodically protected	1. Double Polyethylene Encasement	1. Double Polyethylene Encasement	1. Double Polyethylene Encasement
Metallic Fittings and Valves for AWWA C905 PVC Pipe	1. Supply with fusion bonded epoxy coating or bonded coating 2. Cathodically protected	1. Supply with fusion bonded epoxy coating or bonded coating 2. Cathodically protect	1. Double Polyethylene Encasement	1. Double Polyethylene Encasement
SPECIAL FITTINGS				
A. Tapping Saddle	All bronze or install in the same manner as metallic fittings above	All bronze or install in the same manner as metallic fittings above	All bronze or install in the same manner as metallic fittings above	All bronze or install in the same manner as metallic fittings above
B. Repair Clamps	1. Stainless steel 2. Install galvanic anode	1. Stainless steel	1. Stainless steel	1. Stainless steel
C. Bolt Nut and Washers Stainless Steel--ASTM F738 Silicon Bronze--ASTM F467 and F468	1. Stainless steel or silicon bronze 2. Cathodically protect with fitting	1. Stainless steel	1. Stainless steel	1. Stainless steel
D. Galvanic Anodes	Zinc or Magnesium	Magnesium	None Required	None Required

Table 4
ELECTRICAL ISOLATION PROCEDURES FOR ALL CONNECTIONS

	Ductile Iron with PW	Ductile Iron (Bare)	Ductile Iron (Coated)	Grey Iron (Bare)	Concrete Cylinder	Copper	Pump Station	Blowoff	Air Release Valves	Pipe Laid w/in Casing
Ductile Iron w/PW	(f)	Insulate	Insulate	Insulate	Insulate	Insulate at Tap	Insulate	Insulate (c)	Insulate (c,d)	Insulate (e)
Ductile Iron - Bare	Insulate	Do not Insulate .	Insulate	Do Not Insulate	Insulate	Insulate at Tap	Insulate	Insulate (c)	Insulate (c,d)	Insulate (e)
Ductile Iron - Coated	Insulate	Insulate	(a,b,f)	Insulate	Insulate	Insulate at Tap	Insulate	Insulate (c)	Insulate (c,d)	Insulate (e)
Grey Iron - Bare	Insulate	Do not Insulate	Insulate	Do not Insulate	Insulate	Insulate at Tap	Insulate	Insulate (c)	Insulate (c,d)	Insulate (e)
Concrete Cylinder	Insulate	Insulate	Insulate	Insulate	(a,b)	Insulate at Tap	Insulate	Insulate (c)	Insulate (c,d)	Insulate (e)
Copper	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Do not Insulate	Insulate at Tap	N/A	N/A	Insulate (e)
PVC	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate
Cement Asbestos	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate	Do Not Insulate

a - Line insulation may be required for project of considerable length.
b - Insulate at perpendicular conditions.
c - No insulation required if the air valve/blow-off pipe and coating is the same as the main piping.
d - Except at air valves located in vaults.
e - Insulate from the casing.
f - Insulate distribution pipe from 24-inch and larger pipe.
PW - Polyethylene encased.
N/A - Not applicable

Part 3
PIPE COATINGS

SECTION 1--REQUIREMENTS

1.1 General: As part of the external corrosion protection of the buried pipe used in the water system, the metallic pipe and appurtenances require external coatings. The external coating requirements for each type of pipe also depends on the corrosion ratings, and are specified below.

1.2 Materials:

1.2.1 Bonded Tape Coating: Bonded tape coating shall be either factory applied or field applied tape coating.

1.2.1.1 Factory Applied Bonded Tape Coating: All standard pipe lengths shall have a factory applied bonded tape coating. The bonded tape coating shall have a primer layer, an inner layer (19 mils minimum thickness) for corrosion protection, and an outer layer (27 mils minimum thickness) for mechanical protection. The contractor shall provide manufacturer's certification that the bonded tape coating conforms to AWWA standard C214a. This standard is for steel pipe, but shall be used with ductile iron pipe.

1.2.1.2 Field Applied Bonded Tape Coating: Field applied tape coatings shall be as per AWWA standard C209 (This standard is for steel pipe, but shall be used with ductile iron pipe). Field applied bonded tape coating shall be made just prior to backfilling, using a three layer cold applied bonded tape coat system with a 50 percent overlap for a minimum thickness of 46 mils. The field applied bonded tape coating system shall overlap the factory applied tape coating a minimum of six inches in all places.

1.2.2 Polyethylene Wrap: The polyethylene shall be manufactured of virgin polyethylene material. It shall have a minimum thickness per layer of 8 mils and be in tube form. The polyethylene wrap shall conform to AWWA Standard C105 and installed using Method A or B.

1.2.3 Fusion-Bonded Epoxy: The fusion bonded coating shall consist of a one-component powdered, fusion-blend material consisting of epoxy resin, curing agents, catalyst, fillers, colorants, and flow control agents. When applied, the preheated substrate will melt, fuse, and subsequently cure to produce a coating complying with the requirements in AWWA Standard C213. When applied by electrostatic spray, fluid bed, or air spray to the preheated fitting and subsequently cured, the epoxy powder shall produce a uniform protective coating 15 to 20 mils thick.

1.2.4 Coal Tar Epoxy: The coal tar epoxy shall be 100 percent solids; apply coating at a rate of 60 square feet per gallon (26 mils dry film thickness), or 74 percent solids applied to 30 mils (MDFT); a minimum of three coats should be applied to the exterior of the freshly placed cement-mortar coating. The coating shall be installed without runs, sags, misses, etc.

1.3 Addition Materials For Concrete Cylinder Pipes And Fittings: For Corrosion Rating 1 only, concrete cylinder pipes and fittings shall also be furnished with the following:

1.3.1 Type II Modified Cement: In soils with sulfate concentrations exceeding 2,000 ppm, cements

with less than 5 percent of tricalcium aluminate (Type II modified cement) must also be used.

1.3.2 Supplemental Protection: A supplemental protection such as pozzolan addition shall be required when sulfates exceed 5,000 ppm.

SECTION 2 - INSPECTION/REPAIR

2.1 General: The various coatings shall be inspected and repaired by the manufacturer at the coating yard in accordance to their standard specifications.

2.2 Field Inspection and Repair: The contractor shall provide manufacturer and supplier certification that coatings are in accordance with the specifications specified herein. Any field repairs to coatings shall be done by the contractor at no cost to the Department of Water Supply.

2.3 Bonded Tape Coating: Each factory applied bonded coated pipe shall be electrically tested for flaws and shipping damage by means of a suitable high voltage holiday detector before installation. A visual inspection of the factory applied coating shall be made after installation and before backfilling. Field applied bonded coatings shall be holiday inspected just prior to backfilling. The electrical inspection test and holiday inspection shall be performed by the contractor and be in accordance with NACE Standard RP-0274-74. All coating flaws shall be repaired in accordance with AWWA standard C214a.

2.4 Polyethylene Encasement: The coating shall be visually inspected after installation and before backfilling. All coating flaws shall be repaired in accordance with the coating manufacturer's recommendations. Extra care must be taken during backfilling operations to ensure that the coating is not damaged.

2.5 Coal Tar Epoxy: The coating shall be visually inspected and all flaws in the coating shall be repaired in accordance with the coating manufacturer's recommendations. The coating repair shall be kept dry and shall be fully cured before backfilling.

2.6 Fusion-Bonded Epoxy: The coating shall be visually inspected and all flaws in the coating shall be repaired in accordance with the coating manufacturer's recommendations. The coating repair shall be kept dry and shall be fully cured before backfilling.

Part 4
CATHODIC PROTECTION DESIGN

SECTION 1--REQUIREMENTS

1.1 **General:** As part of the external corrosion protection of the buried pipe used in the water system, some of the metallic pipe, valves and fittings require cathodic protection. The cathodic protection requirement for each type of pipe depends on the corrosion rating. Cathodic protection shall be required for pipes, valves, and fittings when corrosion ratings 1 and 2, (Table 2) are encountered.

SECTION 2 - DESIGN

2.1 **Design:** The design shall utilize a galvanic anode type cathodic protection system or an impressed current system. The design shall be in accordance with accepted practice and NACE Standard RPO169-83. The cathodic protection design shall have a theoretical life of 20 years. The design shall be approved by the Manager.

Part 5
CORROSION CONTROL PRODUCTS

SECTION 1--MATERIAL

1.1 **General:** This section covers the material necessary to furnish and install joint bonds to form an electrically continuous pipeline, galvanic cathodic protection system, test stations, insulated joints, and casing insulators.

Like items of materials provided hereunder shall be the end product of one manufacturer to achieve standardization for appearance, maintenance, and replacement.

Materials and workmanship as specified in this section shall be installed concurrently with pipe installation.

The use of a manufacturer's name and model or catalog number is only for the purpose of establishing the standard of quality and general configuration desired. Products of other manufacturers will be considered.

1.2 **Joint Bond Wires:** Joint bond wires shall be single-conductor, stranded copper wire with 600-volt HMWPE insulation. Supply all joint bonds complete with a formed copper sleeve on each end of the wire.

- Push-on, Mechanical, Ball or Flange Joints--No. 2 AWG wires, 18 inches long.
- Flexible Coupling Joints--No. 2 AWG wires, 24 inches long, with two 12-inch long insulated No. 12 AWG wire pigtails, as manufactured by Erico Products, Inc. (Cadweld), Cleveland, Ohio, or the equivalent.
- Insulated Flexible Coupling Joints--No. 2 AWG wire, 18-inch long, with one 12-inch long No. 12 AWG wire pigtail.
- Concrete Cylinder Pipe--Joint bonds shall be supplied by the manufacturer and shall include the following:
  - Shop welded studs or plates on both the pipe bell and spigot, as shown. Studs shall be welded to the bell-and-spigot by the pipe manufacturer at a spacing of 1/8 steel cylinder circumference.
  - AWG bond wires, for each joint. Bond wires shall be No. 1/0 AWG 9 inches long with sufficient insulation removed from each end of the wire to allow field welding.

1.3 **Galvanic Anodes:**

1.3.1 High Potential Magnesium Alloy: (Corrosion Rating 2 through 5)

- Composition:

Aluminum	0.010 percent maximum
Manganese	0.500 to 1.300 percent
Zinc	0
Silicon	0
Copper	0.020 percent maximum
Nickel	0.001 percent maximum
Iron	0.030 percent maximum
Total Others	0.050 percent each or 0.300 percent maximum, total
Magnesium	Remainder

1.3.2 Zinc Anodes (ASTM B418, Type I): (Corrosion Rating 1)

- Composition:

Iron	0.005 percent maximum
Cadmium	0.030 to 0.100 percent
Aluminum	0.100 to 0.400 percent
Zinc	Remainder

1.3.3 Compliance Statement: Furnish an independent laboratory analysis guaranteeing that all anodes supplied meet all the requirements of this Specification.

1.3.4 Anode Wire: Supply each anode with No. 12 AWG solid copper wire with THWN insulation, 10-feet long.

1.3.5 Wire-to-Anode Connection: Manufacturer's standard. The anode connection shall be stronger than the wire.

1.3.6 Backfill Composition:

• Ground Hydrated Gypsum	75 percent
• Powdered Wyoming Bentonite	20 percent
• Anhydrous Sodium Sulfate	5 percent

1.3.7 Backfill: Backfill shall have a grain size so that 100 percent is capable of passing through a 20-mesh screen and 50 percent will be retained by a 100-mesh screen. The backfill mixture shall be thoroughly mixed and firmly packaged around the galvanic anode within the cloth bag by means of adequate vibration. The complete package shall weigh a minimum of 2.25 times the bare anode weight.

1.3.8 Packaging and Shipping: Provide electrode packaged in a plastic or heavy paper bag of sufficient thickness to protect the electrode, backfill, and cloth bag during normal shipping and handling.

1.4 **Cathodic Protection Test Station:**

1.4.1 Flush Mounted:

- Test Box--Concrete body cast with a cast iron ring, with a minimum weight of 55 pounds and minimum dimensions of 8-inch inside diameter and 12-inch length. Provide extensions as required to penetrate concrete surfaces by 4 inches minimum. Provide with a 12-pound cast iron lid with the words " BWS Test Station" cast into the lid. Test boxes in unpaved non-traffic areas shall require valve markers.

- Terminal Block--Plastic or glass-reinforced, 1/4-inch thick laminate terminal board with minimum dimensions of 6-inch by 8-inch. Provide terminal block with five nickel-plated brass studs, washers, and lock washers.

1.4.2 Test Station Wires:

- Wire: Single conductor, No. 12 AWG stranded copper with 600-volt TW, THWN, or THHN insulation and single-conductor, No. 8 AWG stranded copper with 600-volt TW, THWN, or THHN insulation.

1.5 **Permanent Reference Electrodes:**

1.5.1 Prepackaged Zinc Reference Electrodes

- Material: ASTM B418, Type II.

- Dimensions: 1.4 inches by 1.4 inches by 9 inches.

- Wire: No. 12 AWG stranded copper wire with yellow, 600-volt TW, THWN, or THHN insulation. The wire shall be a minimum of 25 feet long and attached to the electrode core by the manufacturer's standard connection. Connection shall be stronger than the wire.

- Backfill: 50 percent gypsum, 50 percent bentonite, in a permeable cloth bag, or approved equivalent.

- Packaging: Provide electrode packaged in a plastic or heavy paper bag of sufficient thickness to protect the electrode, backfill, and cloth bag during normal shipping and handling.

1.6 **Shunts:** 0.01-OHM Holloway Type RS

1.7 **Thermite Weld Materials:**

1.7.1 General: Thermite weld materials shall consist of wire sleeves, welders, and weld cartridges according to the weld manufacturer's recommendations for each wire size and pipe or fitting size and material. All welding materials and equipment shall be the product of a single manufacturer. Interchanging materials of different manufacturers will not be acceptable.

1.7.2 Molds: Graphite. Ceramic "One-Shot" molds will not be acceptable.

1.7.3 Adapter Sleeves: Provide for No. 12 AWG, No. 4 AWG, and No. 2 AWG wires. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in the field are acceptable. Field-formed joint bonds sleeves shall be attached with the appropriate size and type of hammer die provided by the thermite weld manufacturer. Wire conductor shall extend 1/4 inch beyond the end of the sleeve.

1.7.4 Cartridges: Cast iron thermite weld cartridges shall be used for all cast and ductile iron pipe and fittings. Maximum cartridge size shall be 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.

1.8 **Ground Clamp:** Ground clamp shall be sized to fit the copper tubing and wire size, made out of high copper alloy, and rated for direct burial.

1.9 **Thermite Weld Caps:** Prefabricated weld cap with coating and suitable primer.

1.10 **Pipe And Fitting Coating Repair Material:** As recommended by the pipe or fitting coating manufacturer. Repair coating for spot damage at thermite weld connections not covered by standard pipeline coating repair procedure, or thermite weld cap shall be 100 percent solids epoxy that can cure in submerged or buried conditions.

1.11 **Wire Connectors:** One-piece, tin-plated crimp-on lug connector.

1.12 **Electrical Tape:** Linerless rubber high-voltage splicing tape and vinyl electrical tape suitable for moist and wet environments.

1.13 **Insulated Joints:** Insulating joints shall be dielectric unions, flanges, or couplings. The complete assembly shall have an ANSI rating equal to or higher than that of the joint and pipeline. All materials shall be resistant to the intended exposure, operating temperatures, and products in the pipeline.

1.13.1 Flange Insulating Kits:

- Gaskets--Full-face Type E with O-ring seal. The flange gasket shall be supplemented with neoprene facing on each side to create a seal.
- Insulating Sleeves--Full-length Mylar.
- Insulating Washers--High-strength phenolic.
- Washers--Same material as bolts, 1/8-inch thick.

1.13.2 Flexible Insulated Couplings: Cast coupling with insulating boot gasket.

1.13.3 Insulating Unions: O-ring sealed with molded and bonded insulating bushing to union body.

1.13.4 Service Insulators: High silicon bronze and insulating bushing.

1.14 **Casing Insulators:** Casing insulators shall be molded high-density polyethylene with plastic runners and shall consist of bolted segments, complete with stainless steel bolts for assembly.

1.15 **Casing Seals:** Casing seals shall be flexible molded rubber seals and shall be supplied complete with two stainless bands for sealing. Split seals are not acceptable.

1.16 **Wall Seals:** Wall seals shall be interlocking links of molded synthetic rubber. The links are to be connected together with stainless steel bolts. The wall seal shall be sized for the pipe size and type and the wall hole.

1.17 **Replacement Provisions:** Upon completion of the installation, the contractor shall be required to furnish and deliver to the Department of Water Supply ten percent (or a minimum of one, whichever is greater) of all external corrosion control items (joint bonds, test leads, anode wires, galvanic anodes, test stations - each type, zinc reference electrodes, shunts, thermite weld materials, ground clamps, thermite weld caps, wire connectors, electric tape, and insulated joints), used or installed as part of the project. Catalog cuts, manufacturer's MSDS sheets, installation instructions and ordering information shall be provided for all external corrosion control items used or installed.

SECTION 2--SUBMITTALS

2.1 **General:** Six (6) set of the following items shall be submitted and approved by the Manager prior to the installation of any cathodic protection equipment and/or material:

- A complete list of equipment and material, including name and manufacturer, catalog number, size, finish and any other pertinent data necessary for proper identification and to determine conformance with the plans and specifications.
- Catalog cuts for all anode backfill material including chemical analysis.
- A catalog cut showing the chemical analysis for all anodes.
- A catalog cut showing the chemical analysis for all zinc permanent reference electrodes used.
- A catalog cut by the wire manufacturer covering conformance of wire insulation to designated specifications.

Part 6
CORROSION CONTROL EXECUTION

SECTION 1--WORKMANSHIP

1.1 **General:** Installation of the facilities specified and described shall conform to the latest applicable rules as set forth herein and shall be furnished and installed by the contractor. Any changes in design or method of installation of any item as specified shall be reviewed and approved by the Manager before installation.

The Contractor shall coordinate the installation of the specified items such that installation of the items herein specified can be completed concurrently with pipeline installation. Items not installed before backfilling of the pipe shall be installed at the Contractor's sole expense.

Whenever the requirements of the Specifications or Drawings exceed those of the codes or manufacturer's instructions, the requirements of the Specifications or Drawings shall prevail. Where a larger size or better grade of material or a higher standard of workmanship is required, the most stringent requirement shall apply.

1.2 **Pipe Joint Bonding:** To form an electrically continuous pipeline and associated valves and fittings, the joints of all buried metallic pipe, including vault and manhole piping and all fittings, shall be electrically bonded, except joints specified to be threaded, welded, or insulated.

Install one or two joint bond wire assemblies at each joint that requires bonding, in accordance with Table 3, Part 2, of this document and the following:

Pipe Size	Number of Bond Wires Required
smaller than 24-in diameter	1
24-inch diameter & larger	2

The electrical connection of all wires to pipe and fittings shall be performed using the thermite weld process.

1.3 **Concrete Cylinder Pipe Studs or Plates:** Bonding studs or plates shall be shop welded to both the pipe bell and spigot with full penetration fillet welds without undercutting, gaps, or cracks.

Studs or plates damaged during shipment or handling shall be repaired before installation in a manner approved by the Manager.

1.4 **Anode Storage And Handling:** Store all prepackaged anodes off the ground and keep them dry at all times. Protect them against weather, condensation, and mechanical damage. Immediately remove all wet or mechanically damaged prepackaged anodes from the site. Prepackaged anodes shall be handled with care to prevent loss of backfill material. Anodes shall not be lifted or held by the lead wire.

1.5 **Galvanic Anode Installation:**

1.5.1 General: Remove the plastic or heavy paper bag used for shipping. Install galvanic anodes 5 feet below the pipe invert. Provide a minimum anode spacing of 2 feet from other unprotected pipelines. Install anodes at intervals determined by the cathodic protective design.

Earth backfill around each anode shall be thoroughly compacted to a point 1 foot above the anode. Backfill material around each anode shall be native soil free of roots, organic matter, trash, and rocks. Stop backfill at specified grade to allow for placing of topsoil, when required.

All anode wires shall be buried a minimum of 24 inches below finish grade. Wires shall be handled with care. Splices or damage to the insulation on any wire shall be repaired in accordance with WIRE INSULATION REPAIR, this section.

1.5.2 Pipeline: Location of anodes shall be determined by the cathodic protection design. Electrical connection of the anode wire to the pipe shall be by the thermite weld method.

1.5.3 Buried Pipe, Valves and Fittings For Non-Metallic Pipe: Each buried cast iron fitting, pipe section, and valve used in conjunction with nonmetallic pipe shall be cathodically protected with zinc anodes (corrosion rating 1) or magnesium anodes (corrosion rating 2). Where two or more metallic fittings are adjacent to each other, joint bonds shall be installed as specified in this section, and using the specified quantity or anodes installed on each fitting, pipe, section, or valve.

Anode connections to cast iron fittings and valves shall be made by the thermite weld method. Any damage to the interior coating shall be repaired in accordance with the manufacturer's recommendations.

The anodes shall be spaced equally around the fitting, pipe section, or valve, and shall be located a minimum of 2 feet from the metallic fitting at the bottom edge of the pipeline trench. The number of anodes to be installed on each cast iron fitting, pipe section, or valve shall be:

Pipe Size	Number of Anodes
16 inches or less	1
18 inches to 30 inches	2
32 inches to 48 inches	3
larger than 48 inches	4

At the Contractor's option, larger anodes may be used in place of multiple smaller anodes for any group of bonded metallic components provided that the same total weight is used.

A pipe section is defined as a single fitting or a single piece of pipe less than 20 feet in length. Pipe sections between 20 to 40 feet in length shall be treated as two pipe sections. Each 20 feet of pipe and fittings with joint bonds may be treated as one pipe section.

For pipe and fittings with fusion bonded epoxy coatings, anode requirements shall be reduced by one pipe size. A minimum of one anode is required, however.

1.6 **Test Station Installation:** The general locations of the test stations are shown on the construction plans. The Contractor shall determine the location of the test stations based on actual site conditions and as approved by the Manager.

Test stations shall be located as follows:

- Install Type T test stations or other type test stations as appropriate at 1,000-foot intervals or less.
- Install a Type F test station where any ferrous metal pipe crosses a foreign-owned pipeline 8-inches or larger or under cathodic protection.
- Install a Type C test station at both ends of cased crossings.
- Install a Type I test station at all buried insulated joints.

Test wires shall be attached to the pipe by the thermite weld method. Wires to foreign-owned pipelines shall be attached by the pipeline owner. The Contractor shall coordinate this work with the owner of the foreign pipeline before the pipe is excavated.

Locate flush-mounted test stations above the pipeline.

Wire connections to test station terminals shall be made with crimp-on spade lug terminals, except where solid wire is specified or terminal strips with tubular clamps are used.

Concrete shall be DWS 2500.

1.7 **Reference Electrode Installation:** Remove plastic or paper wrapper and place reference electrode within the pipeline trench excavation 6 inches from below the centerline of the pipe in a vertical or horizontal position. Install the reference electrode within 18 inches of foreign pipelines, between the foreign and BWS pipeline. Reference electrodes shall be backfilled with native trench material. Terminate wires in the test stations.

1.8 **Wire Connections:**

1.8.1 Thermite Weld: The electrical connection of copper wire to steel, ductile, and cast iron surfaces shall be performed using the thermite weld method. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation as recommended by the welder manufacturer. Assure that the pipe or fitting wall thickness is of sufficient thickness that the thermite weld process will not damage the integrity of the pipe or fitting wall or protective lining.

After the weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace any defective connections.

On pipe and fittings with dielectric linings, make the weld connection on the shop tab provided or on a thick metal section to minimize damage to the lining and coating. After the weld is made, coat the weld as specified.
Install a prefabricated thermite weld cap over each completed connection. All exposed metal surfaces not covered by the thermite weld cap shall be repaired in accordance with the coating manufacturer's recommendations. All damage to the pipe lining shall be repaired in accordance with the lining applicator's recommendations.

Wire connections to concrete cylinder pipe shall be made by thermite welding to the shop welded steel studs or plates provided on the pipe for this purpose. Clean the steel studs to bright metal before thermite welding. Coat the completed wire connection with cement mortar as shown on the Corrosion Control Details.

1.8.2 Ground Clamp: The electrical connection of copper wire to copper pipe shall be made by using a high copper alloy ground clamp.

Before the connection is made, the area around the connection shall be cleaned for good connection. The clamp shall be installed tight to the service pipe without crimping or damaging the pipe. The wire shall be connected at the ground wire location of the clamp.

After the connection is completed, coat the finished connections on copper pipe by doing the following:

- A 12-mil total thickness polyethylene backed, butyl rubber adhesive pipeline tape, spirally applied with a 55 percent overlap of succeeding wraps for a distance of 4 inches to each side of the connection.

1.9 **Wire Insulation Repair:** Wires shall be handled with care. Splices for damage to the wire insulation shall be required by spirally wrapping (50 percent overlap, minimum) with two coats of high-voltage rubber splicing tape and two layers of vinyl electrical tape. Wire splices shall be made with suitable sized compression connectors as specified under PRODUCTS, this section, or mechanically secured and soldered. All splices shall be approved by the Manager.

1.10 **Insulated Joints:** Insulated joints shall be installed to electrically isolate the pipeline from other structures as specified in Table 4, Part 2, Volume 3.

Carefully align and install insulating joints according to the manufacturer's recommendations to avoid damaging insulating materials.

1.11 **Casing Insulator and Seals:** At all locations where water system piping is cased with metal casing, casing insulators and end seals shall be installed. Type and spacing of insulators required shall be at manufacturer's written recommendations and depend on type and size of casing and carrier pipe.

SECTION 2–INSPECTION

2.1 **General:** A qualified individual or firm experienced in inspecting the installation of corrosion control systems, acceptable to and approved by the Department shall be employed by the Contractor to inspect the installation of the external corrosion control system.

2.2 **Qualifications:** The Contractor shall submit the names(s) and qualifications of all personnel and/or subcontract firm planned for the inspection work. All personnel must be approved beforehand by the Department. Inspection personnel shall be under the direct supervision of a Registered Professional Corrosion Engineer or a Corrosion Specialist certified by the National Association of Corrosion Engineers.

Part 7
TESTING

SECTION 1–EQUIPMENT

1.1 **General:** Before construction begins, the contractor shall obtain the test equipment necessary for performing all tests specified herein.

The test equipment shall be stored at the project site for the Contractor's use and shall be maintained in accurate working condition at all times. The test equipment shall be available to the Manager for testing purposes.

1.2 **Required Equipment:** The following equipment is required to perform the testing of external corrosion control material and installation:

1.2.1 Joint Bonds Before Backfilling:

- Biddle Model 247001 digital low resistance ohmmeter
- Set of duplex helical current and potential hand spikes, Biddle Model No. 241001, cable length as required
- One calibration shunt rated at 0.001 ohms, 100 amperes, Biddle Model No. 249004

1.2.2 Joint Bonds After Backfilling:

- One dc ammeter (meter or clamp-on) with full scale reading of 100 amperes and a minimum resolution of 1 ampere or a 100-ampere shunt with a voltmeter as specified herein
- One high-resistance electronic voltmeter with a dc low range of 200 millivolts full scale to a dc high range of 20 volts full scale and capable of a minimum resolution of 1 millivolt (two voltmeters are required if a shunt is used)
- One knife switch, safety switch, or time-controlled relay suitable for test current
- Two electrical probes for the voltmeter
- Insulated wire suitable for carrying the test current, length as required
- One dc power supply with a steady capacity of 25 amperes minimum; storage batteries are not an acceptable power supply

1.2.3 Insulated Joints and Casing Insulation

- Gas Electronics Model 601 for above ground insulators and/or 702 insulation checker for buried insulators

1.2.4 Test Station/Reference Electrode/Cathodic Protection System:

- A Beckman Model HD-100, Digital Multimeter, with case and test leads, or the equivalent
- Two Model 6B copper-copper sulfate reference electrodes
- Copper sulfate crystals and solution

SECTION 2 - REQUIRED TEST & RECORD KEEPING

2.1 **General:** The Contractor shall furnish all necessary equipment and material required to perform all tests described herein. The Contractor shall also employ qualified individuals or a firm experienced in this type of work, acceptable to and approved by the Department. The Contractor shall submit the name(s) and qualifications of all personnel and/or subcontract firm planned for the testing. All personnel shall be approved beforehand. Test personnel shall be under the direct supervision of a Registered Professional Corrosion Engineer or a Corrosion Specialist certified by NACE.

2.2 **Electrical Continuity Testing:** Conduct a continuity test on all buried joints that are required to be bonded both before backfilling and after backfilling.

2.2.1 Before Backfilling: The Contractor shall test electrical continuity of completed joint bonds before backfilling using either a digital low resistance method.

2.2.1.1 Test Procedure: Measure the resistance of joint bonds with the low resistance ohmmeter in accordance with the manufacturer's written instructions. Use the helical hand spikes to contact the pipe on each side of the joint without touching the thermite weld or the bond. The contact area shall be cleaned to bright metal by filing or grinding and be without any surface rusting or oxidation.

2.2.1.2 Record Keeping: Records shall be made of each bonded pipeline during the test and submitted to the Manager. These records shall include description and size of pipeline tested, date tested, joint type, number of joint bonds, joint bond resistance. A typical data sheet is shown in Figure 5, attached at the end of this section.

2.2.1.3 Joint Bond Resistance: The joint bond resistance shall be less than or equal to the maximum allowable bond resistance values shown in Table 5.

Table 5

Joint Type	Maximum Allowable Resistance	
	1 Bond/Joint	2 Bonds/Joint
Push-on or Mechanical	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm
Concrete Cylinder	0.000250 ohm	0.000125 ohm

The Contractor shall replace any joint bond which exceeds the allowable resistance. Replacement joint bonds shall be retested for compliance with the specified bond resistance.

2.2.2 After Backfilling: The Contractor shall retest the continuity on all pipelines required to be bonded after the pipeline has been buried.

2.2.2.1 Test Procedure: The test set-up is shown in Figure 6. The current wires shall be tightly clamped to the No. 8 wire in the test station. Wire size shall be determined by the Contractor and shall be sized for the test current (minimum of 25 amperes). The continuity resistance shall be calculated as shown on the attached data sheet, Figure 7. Continuity will not be accepted if more than 100 percent.

2.2.2.2 Record Keeping: Records shall be made of each section of bonded pipe during the test and submitted to the Manager. These records shall include description, location, and size of pipeline tested, starting location and direction of test, date of test, resistance of pipe per foot, length of pipe tested, measured resistance, calculated resistance, and percent of variance.

2.2.2.3 Resistance: The continuity resistance will not be accepted if calculated to be more than 100 percent. The resistance of the pipe per foot shall be obtained from the pipe manufacture.

If a section of pipe does not pass the continuity test, the Contractor shall locate the defective joint bond and repair it. After repairing the continuity of that section will be retested.

2.3 **Insulation Joints and Casings:** The Contractor shall test each insulated joint and cased crossing with the insulator tester in accordance with the manufacturer's written instructions. All damaged or defective insulation parts shall be replaced and retested. All electrical shorts to the casing shall be cleared and retested.

2.3.1 Record Keeping: Records shall be made of all insulated joint and cased crossing test and submitted to the Manager.

2.4 **Test Station/Electrodes:** The Contractor shall test all test leads and permanent reference electrodes to ensure they were installed in accordance with the specifications. All defective test leads or reference electrodes shall be repaired and/or replaced and retested.

2.4.1 Record Keeping: Records shall be made of all test station and reference electrode tested and submitted to the Manager. A typical set up and data sheet is shown in Figures 8 and 9.

2.5 **Cathodic Protection System:** The Contractor shall test all cathodically protected pipelines to ensure that the protection levels are within the most recent NACE RPO169-83 standards.

2.5.1 Record Keeping: Records shall be made of all anode current output and pipe-to-soil potential measurements performed and submitted to the Manager. A typical data sheet is shown in Figure 10, attached at the end of this section.

2.6 **Acceptance:** All test results shall be submitted to the Manager for reviewed and approval before the corrosion control work is accepted. The Registered Professional Corrosion Control Engineer (or the Corrosion Specialist) shall submit a summary report to include basic statements regarding the operational performance of the cathodic protection system and the other corrosion control provisions. The Manager reserves the right to spot check any or all tests performed by the Contractor. All construction defects must be repaired and retested before the final acceptance is made. All unacceptable test must be reperformed by the Contractor at no additional cost to the Department. At the conclusion of the project, the Registered Professional Corrosion Engineer (or the Corrosion Specialist) together with the Contractor, shall submit a cosigned Certification stating that the pipeline cathodic protection system has been installed according to the plans and specifications, and that the protection levels are within the most recent NACE RPO169-83 standards for the type of pipeline and appurtenances.

SECTION 3-TRAINING

3.1 General: The Contractor shall be responsible for instructing Department of Water Supply personnel (5 or 6 people) on the proper operation, testing and maintenance of all corrosion control items used on the project.

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE TYPE: _____

PIPE SIZE: _____ BY: _____

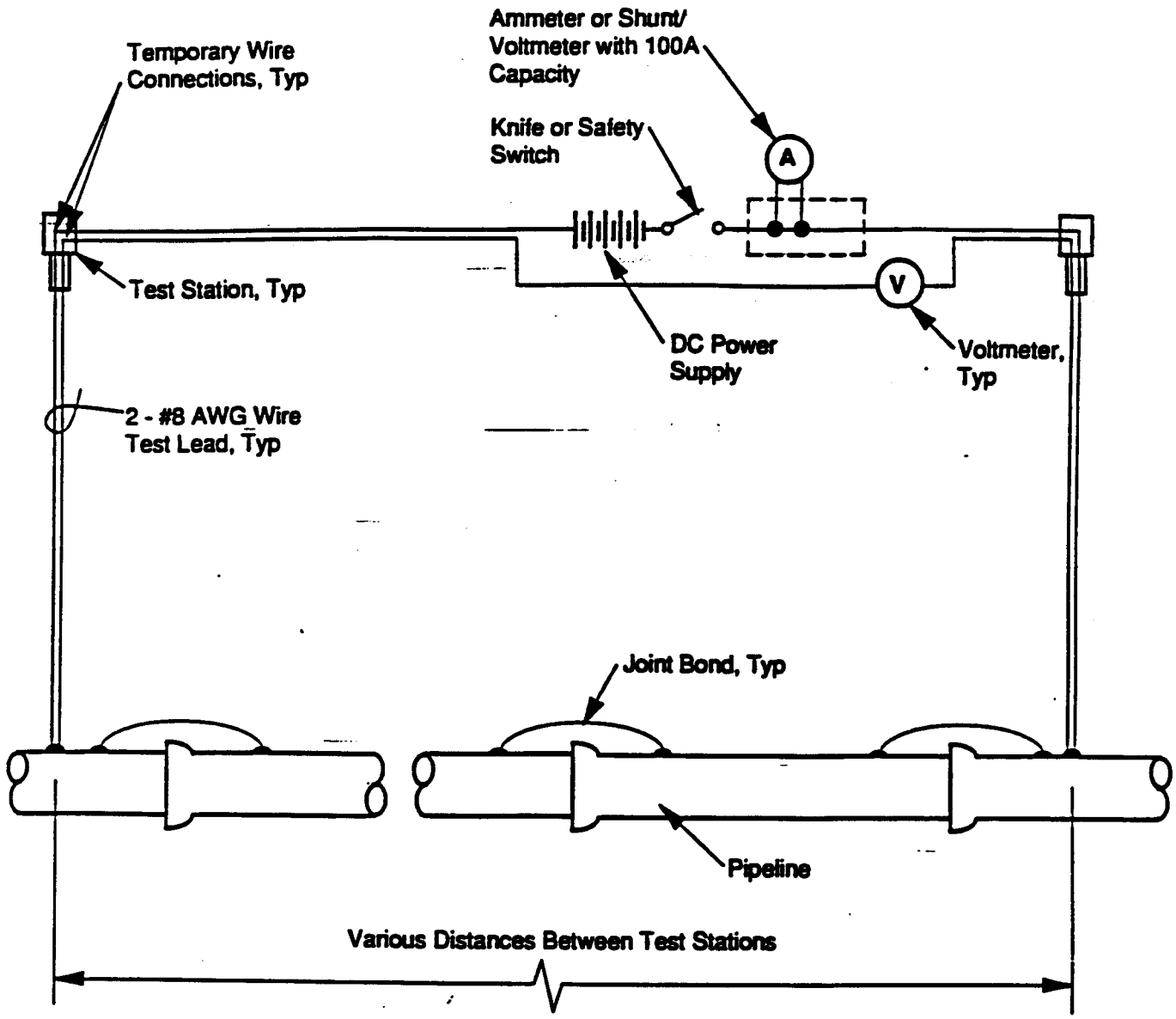
JOINT BOND RESISTANCE TEST.

DATE TESTED	JOINT LOCATION (PIPE STATIONING)	JOINT TYPE	NO. OF BOND WIRES	BOND RESISTANCE	PASSED YES | NO

NOTE: < 24 in. Diameter — 1 Bond Wire Required
24 in. Diameter and Larger — 2 Bond Wires Required

JOINT TYPE	MAXIMUM ALLOWABLE RESISTANCE	
	1 Bond/Joint	2/Bonds/Joint
Push-on or Mechanical	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm
Concrete Cylinder	0.000250 ohm	0.000125 ohm

Figure 5



NOTES:
1. Perform test on each pipe section between test stations.
2. Apply a minimum direct current of 25 amperes.
3. The power source shall supply a constant amperage throughout the test procedure.

Figure 6
Continuity Test Schematic

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

BY_____

LONGITUDINAL PIPE RESISTANCE
ELECTRICAL CONTINUITY TEST

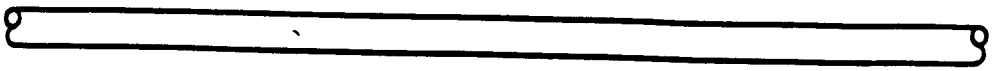
PIPELINE: _____

TESTSPAN _____ TEST NO. _____ DWG NO. _____

TEST SPAN LOCATION _____ STA. NO. _____ TO STA. NO. _____

STREET _____ TOTAL DISTANCE _____ FT.

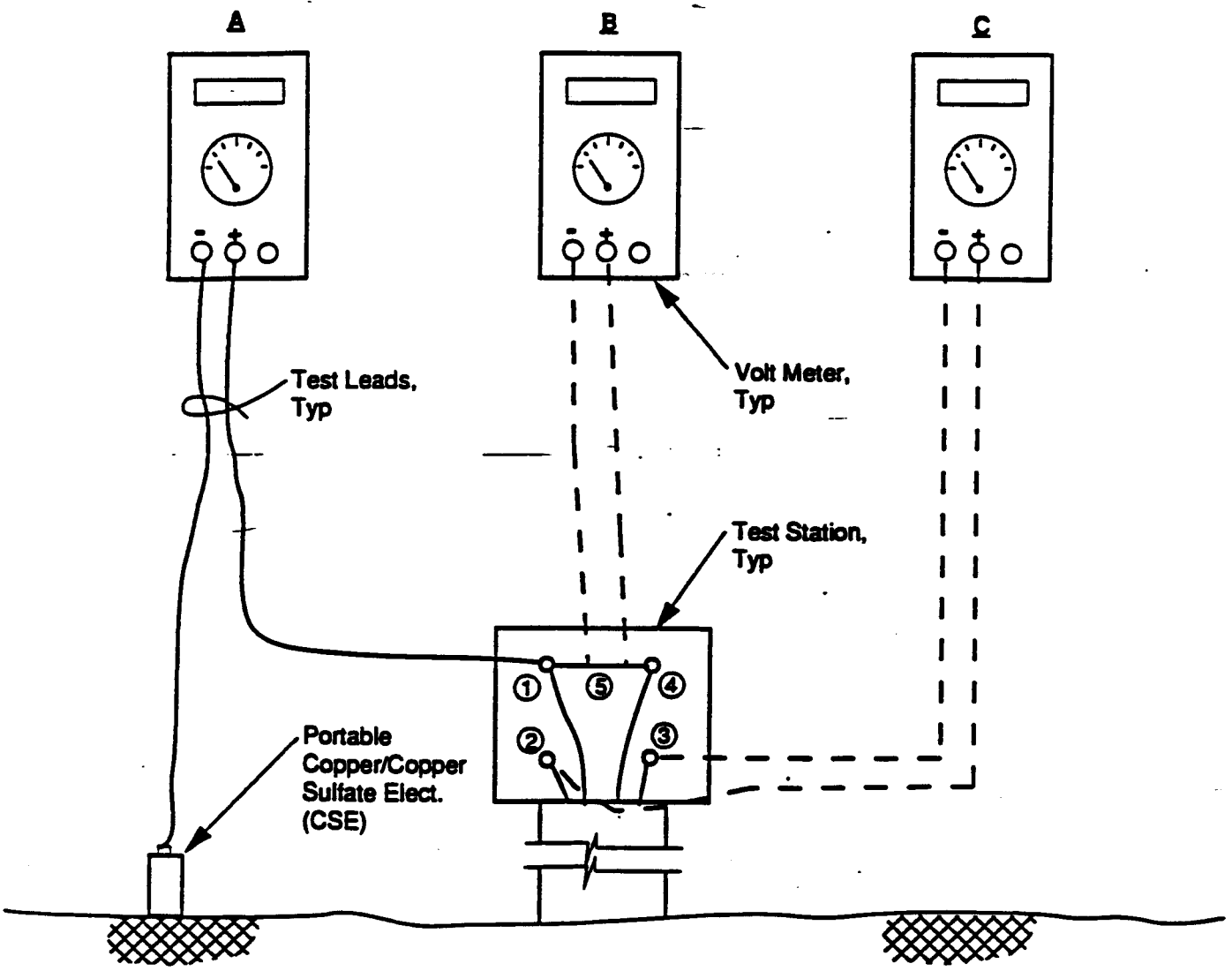
PIPE SIZE _____ TYPE _____ K=CALCULATED RESISTANCE/FT=_____ mΩ



SKETCH (INCLUDE TEST CONNECTIONS, DISTANCES, STATIONING)

TEST POINTS	-	-	-	-	-
VOLTAGE OFF (BEFORE TEST)	FT	FT	FT	FT	FT
VOLTAGE OFF (AT TEST)	mV	mV	mV	mV	mV
VOLTAGE ON	mV	mV	mV	mV	mV
Δ VOLTAGE (OFF-ON)	mV	mV	mV	mV	mV
CURRENT THROUGH SHUNT X FACTOR (IF REQ'D)	mV	mV	mV	mV	mV
CURRENT (I)	A	A	A	A	A
MEASURED RESISTANCE (ΔV/i) R_m	mΩ	mΩ	mΩ	mΩ	mΩ
CALCULATED (D x K FACTOR) RESISTANCE (+ EXTRA) mΩ TOTAL R_c	+_____ mΩ	+_____ mΩ	+_____ mΩ	+_____ mΩ	+_____ mΩ
% (MEAS. R/CAL. R x 100)	%	%	%	%	%
NOTES:					

Figure 7



①& ②- Pipeline Terminals
③ - Permanent Zinc Ref. Elect. Terminal
④ - Anode Terminal
⑤ - 0.01 ohm Shunt

A Potential measurement W/CSE - - volt meter set on 20 dc volts.
Record potentials of each terminal by moving the (+) test lead.
Potentials of ①, ②, &④ should be the same, if shunt is connected.

B Anode current measurement - - volt meter set on 200 dc millivolt.
Record current 1mV = 0.1 amp

C Potential measurement w/zinc elect. - - volt meter set on 20 dc volts.
Record potentials of each terminal by moving the (+) test lead.
Potentials of ①,②, & ④ should be the same, if shunt is connected.

Figure 8
Test Station/Electrode/Anode Current OutputTest Set Up

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

BY_____

TEST STATION/ELECTRODE POTENTIAL MEASUREMENTS

TEST NO.	LOCATION	PIPE (CSE)	ZINC REF. (CSE)	PIPE TO ZINC	CONV. TO CSE

NOTE: Convert pipe to zinc reading to a CSE reading by adding the pipe to zinc reading to zinc ref. to CSE reading.

Example:

-1.10 volt (Zinc Ref. to CSE)
±0.25 volt (Pipe to Zinc)
-0.85 volt (Conv. to CSE)

Figure 9

PIPELINE LOCATION: _____ SHEET____ OF_____

PIPE SIZE:_____ DATE:_____

BY_____

CATHODIC PROTECTION
POTENTIAL MEASUREMENTS

TEST NO.	LOCATION	ZINC TO CSE	PIPE TO ZINC	CONV. TO CSE	ANODE OUTPUT (mA)

NOTES: 1. Convert pipe to zinc reading to a CSE reading by adding the pipe to zinc reading to zinc to CSE reading.

Example:

-1.10 volt (Zinc Ref. to CSE)
±0.25 volt (Pipe to Zinc)
-0.85 volt (Conv. to CSE)

2. Protection Level = -0.85 volt to CSE or more negative.

3. Current reading using 0.01 ohm shunt
1 mV = 0.1 amp

Figure 10

Part 8
PAYMENT

SECTION 1-REQUIREMENTS

1.1 **General:** Unless otherwise specified, payment for the furnishing and application or installation of the external corrosion control system will be made at the unit price bid, or lump sum bid, whichever is specified, for the item of which the external corrosion control is a part. The unit price bid or lump sum bid shall be full compensation for all labor, materials, tools and equipment for all handling, application, installation and other incidental materials and work necessary to place the external corrosion control system in place to complete.

1.2 **Replacement Provisions:** Unless otherwise specified, payment for the furnishing and delivering of all additional external corrosion control items to the Department of Water Supply shall not be made directly but shall be part of the unit price bid, or lump sum bid, whichever is specified, for the item of which the external corrosion control is a part.

Part 9
APPROVED MATERIAL LIST

SECTION 1--MATERIAL

1.1 **General:** The following is an approved material list for corrosion control products. The list also includes an approved list of suppliers that carry most of the items on the list.

The corrosion control products, except category K, P, and R, are all carried by the following suppliers:

- Cathodic Protection Services, Denver, Colorado
- Farwest Corrosion Control, Denver, Colorado
- Wayne Broyles Engineering Corp., Houston, Texas
- Phillips Engineering Corp., Clearwater, Florida
- Harco Technologies Corp., Pearl City, Hawaii

A. Joint Bonds--No. 2 Wire with HMWPE Insulation
   1. Rome Cable Corporation
   2. Kalas Manufacturing, Inc.
   3. Erico Products
      a. Standard Joint = CAF1-1V-12
      b. Flex Coupling = CAD-1V-18

B. Test Lead/Anode Wire With TW, TWHN, or THHN Insulation
   1. Rome Cable Corporation
   2. Kalas Manufacturing, Inc.

C. Galvanic Anodes (High Potential Magnesium)
   1. DOW Chemical USA
      a. 17 Galvomag and 32 Galvomag
   2. Amax Magnesium
      a. 17 Maxmag and 32 Maxmag
   3. Federated Metals
      a. 17A and 32A
   4. Thermal Reduction
      a. 17A and 32A

D. Galvanic Anodes (Zinc)
   1. Federated Metals
      a. 18# and 30#
   2. Thermal Reduction
      a. 18# and 30#

E. Test Station
   1. Brooks Manufacturing
      a. Type 1-RT
   2. Valvco, Inc.
      a. #NM
   3. Hanley Industries, Inc.
      a. T45
F. Zinc Reference Electrodes
   1. Cathodic Protection Services
      a. CPS Standard Package
   2. Farwest Corrosion Control
      a. FWCC Standard Package
   3. Harco Technologies
      a. Standard Package
G. Shunts
   1. Agra Engineering
      a. Type Holoway RS
   2. Cott Manufacturing
      a. Cott Shunt/Yellow
H. Thermite Weld Materials
   1. Erico Products
   2. Continental Industries, Inc.
I. Ground Clamp
   1. Burndy Co.
J. Thermite Weld Cap
   1. Royston Laboratories, Inc.
      a. Handy Cap 2
K. Wire Connectors
   1. Burndy Co.
   2. Thomas and Betts
L. Electrical Tape
   1. 3M Electrical Products Division
      a. Scotch 130C
      b. Scotch 88
M. Flange Insulation Kits
   1. Pipeline Seal & Insulator Inc. (PSI)
   2. Central Plastic Co.
   3. Calpico, Inc.
   4. Pacific Seal Inc.
   5. F.H. Maloney
N. Insulating Unions
   1. Central Plastics
   2. Huber-Yale
      a. Buna-N O-ring
   3. EPCO

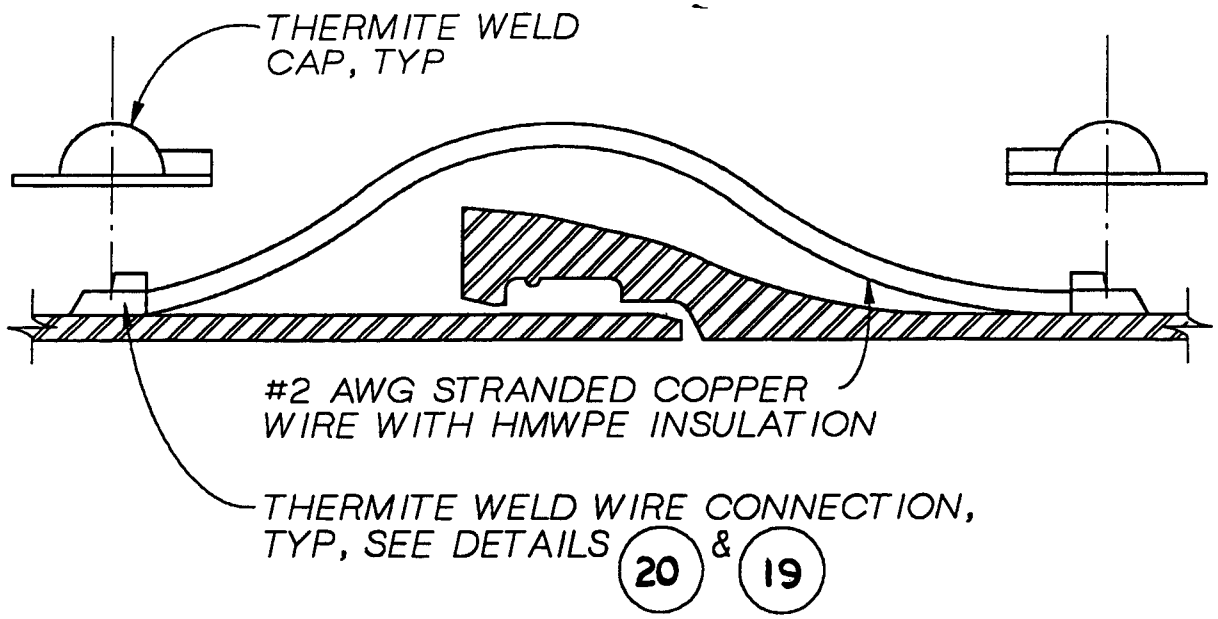
O. Insulating Corporation Stop
    1. Ford Meter Box Co., Inc.
        a. Service Insulator
    2. Mueller Co.
    3. Badger Meter Box 6
P. Casing Insulators
    1. Pipeline Seal & Insulator, Inc. (PSI)
    2. F.H. Maloney
    3. Plastic Products Inc.
Q. Casing Seals
    1. Pipeline Seal & Insulator, Inc. (PSI)
    2. F.H. Maloney
    3. Raychem Corporation
    4. Thunderline Corp.
R. Wall Seals
    1. Thunderline Corp.
        a. Link-Seal
        b. PYRO-PAC

Part 10
CORROSION CONTROL DETAILS

SECTION 1–DETAILS

1.1 **General:** This section includes standard details for external corrosion control for buried pipelines. The details include:

1 Push-on-Joint Bond
2 Flange Joint Bond
3 Flexible Joint Bond
4 Mechanical Joint Bond
5 Ball Joint Bond
6 Concrete Cylinder Pipe Joint Bond
7 Flush Mounted Test Station - Type T
8 Flush Mounted Test Station - Type T with Anode
9 Flush Mounted Test Station - Type I
10 Flush Mounted Test Station - Type F
11 Flush Mounted Test Station - Type C
12 Flush Mounted Test Station - Type C with Anode
13 Galvanic Anode Installation
14 Galvanized Anode at Metallic Fitting for Fire Hydrant Locations on PVC Water Mains
15 Typical Galvanic Anode at Fittings (For Non-Metallic Pipe)
16 Typical Galvanic Anode at Valve (For Non-Metallic Pipe)
17 Ductile or Cast Iron Pipe Anode (For Non-Metallic Pipe)
18 Galvanic Anode at Leak Repair Clamp
19 Thermite Weld Wire Connection
20 Wire Connection for Ductile Iron Pipe
21 Concrete Cylinder Pipe Test Wire Connection
22 Wire Connection to Copper Pipe
23 Insulating Flange
24 Insulated Flexible Coupling
25 Insulated Union
26 Cased Crossing

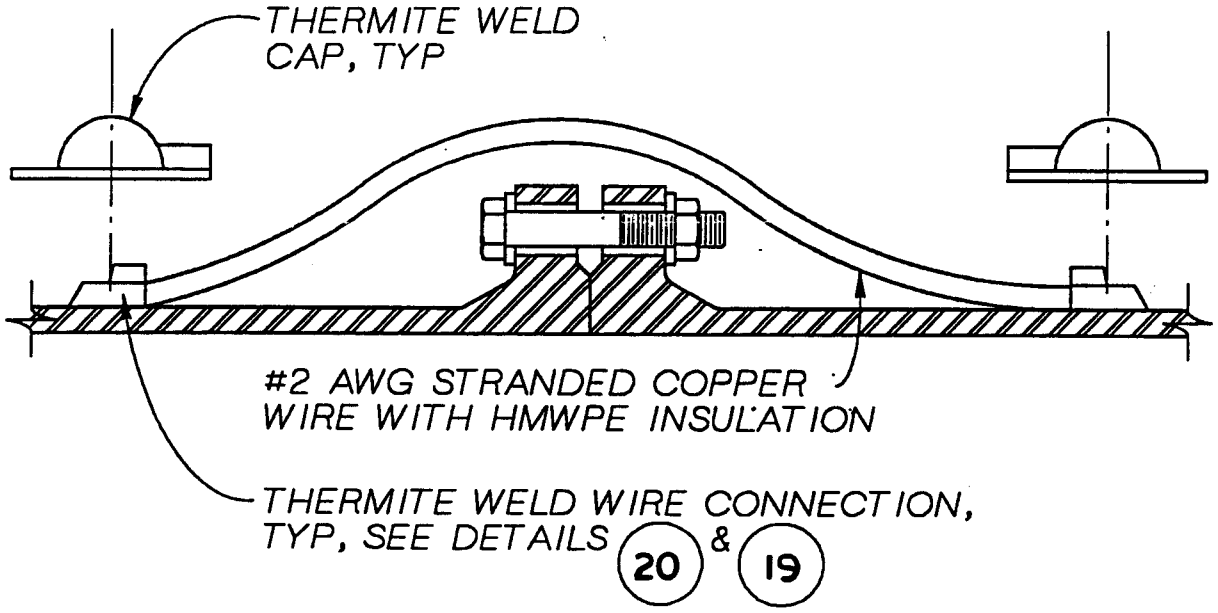


INSTALL TWO BOND WIRES AT EACH PIPE JOINT ON PIPE 24 INCHES LARGER.

PUSH-ON JOINT BOND

NTS

1

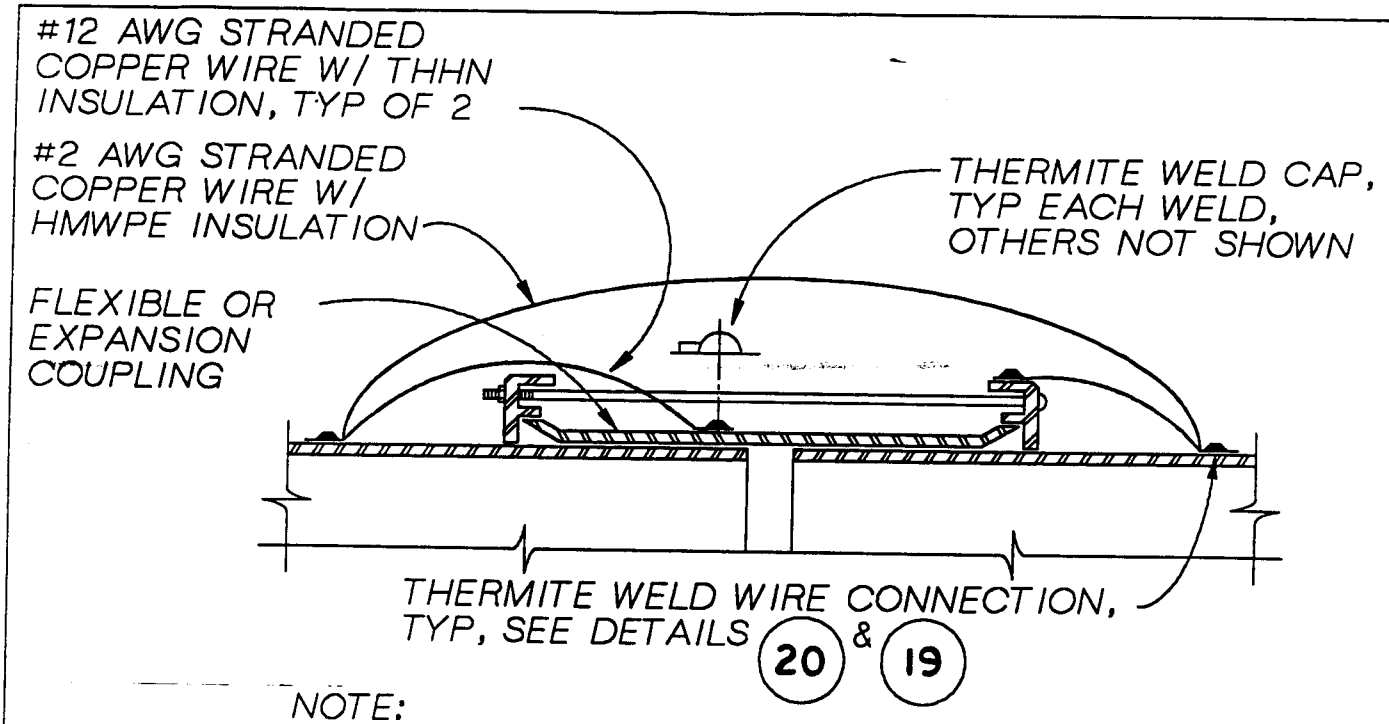


NOTE:
INSTALL TWO BOND WIRES AT EACH PIPE JOINT ON PIPE 24 INCHES LARGER.

FLANGED JOINT BOND

NTS

2

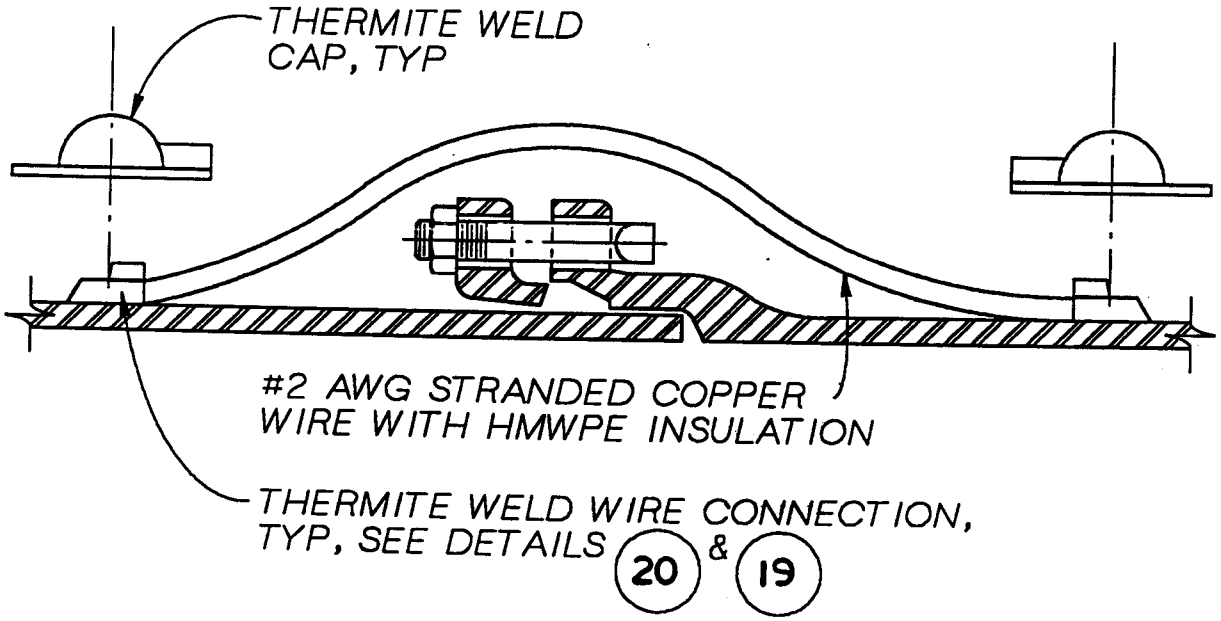


NOTE:
INSTALL TWO BOND WIRES AT EACH PIPE JOINT ON PIPE 24 INCHES LARGER.

FLEXIBLE JOINT BOND

NTS

3

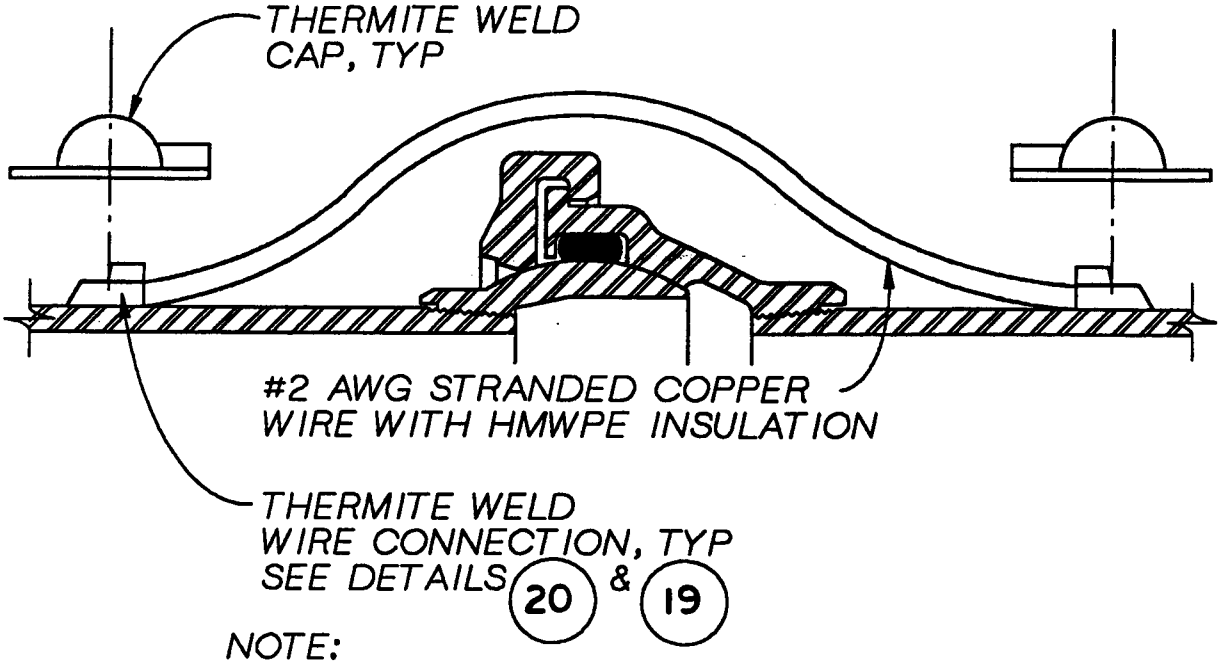


NOTE:
INSTALL TWO BOND WIRES AT EACH PIPE JOINT ON PIPE 24 INCHES LARGER.

MECHANICAL JOINT BOND

NTS

4

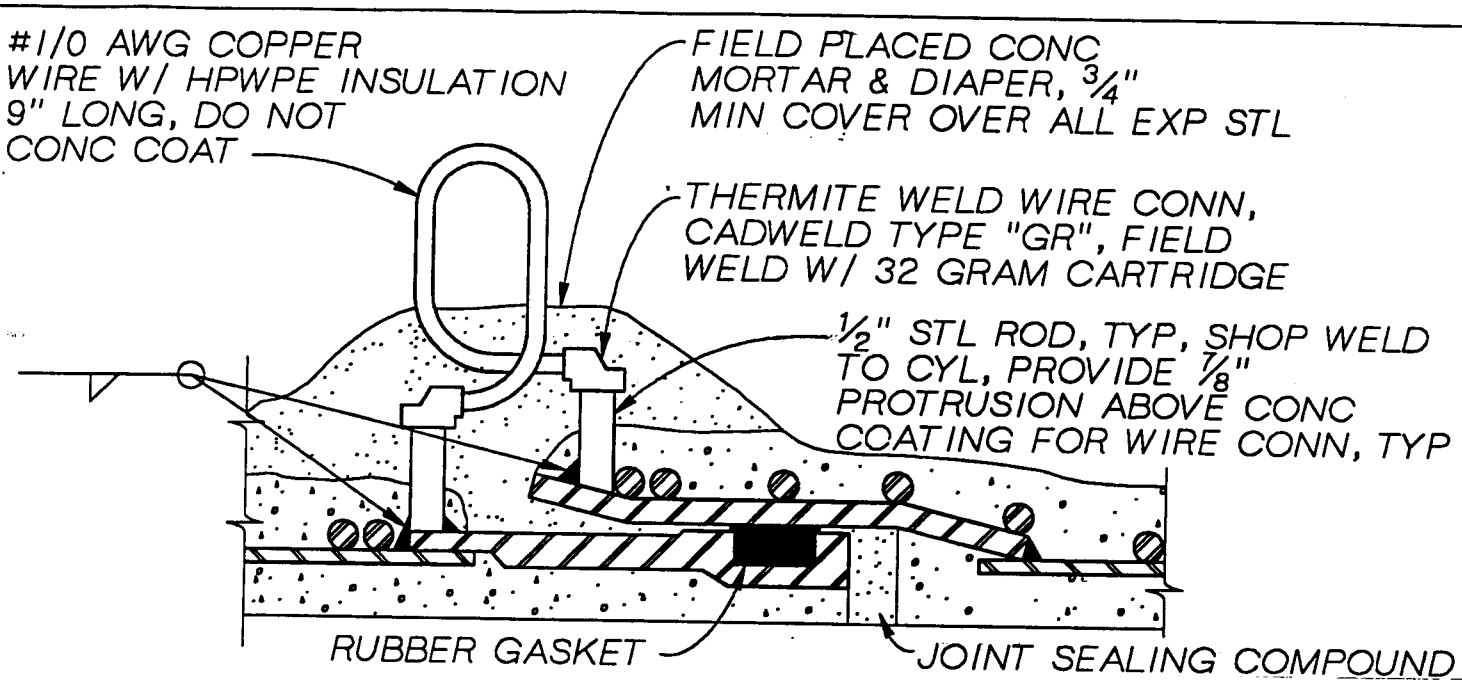


NOTE:
INSTALL TWO BOND WIRES AT EACH
PIPE JOINT ON 24 INCH OR LARGER

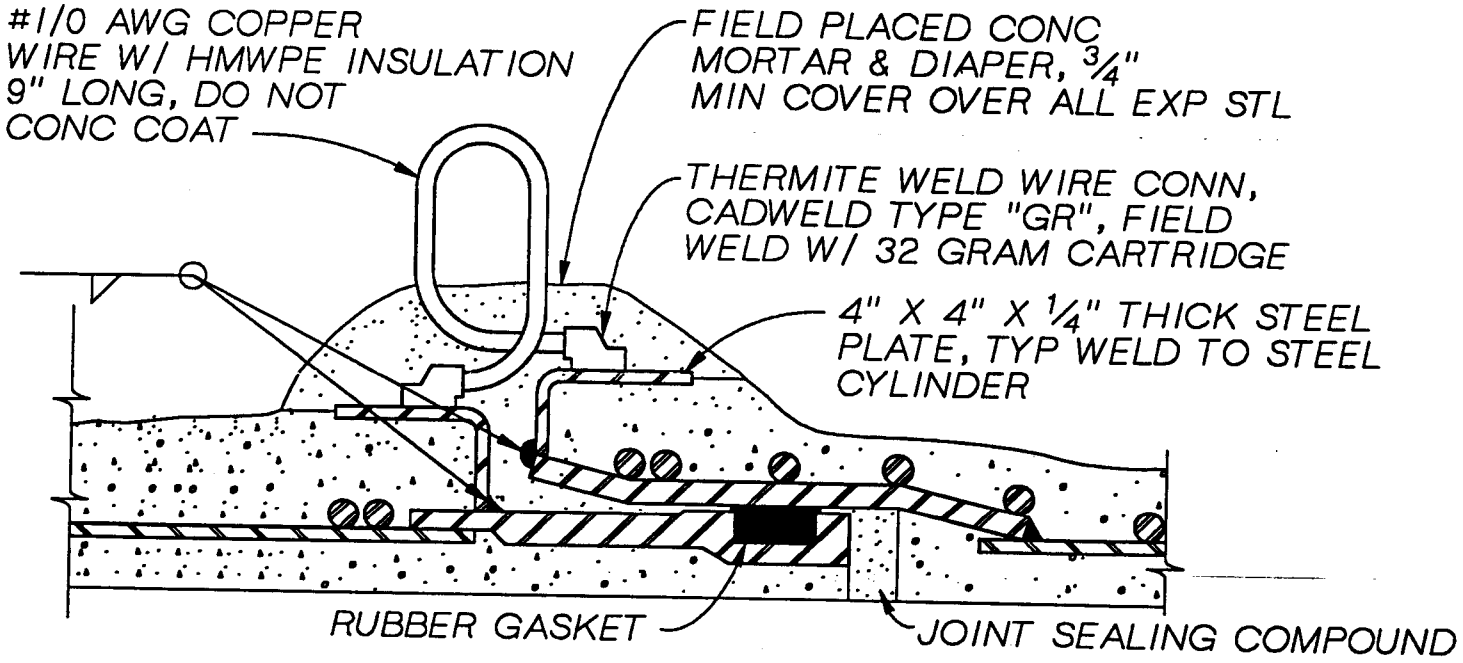
BALL JOINT BOND

NTS

5



METHOD 1



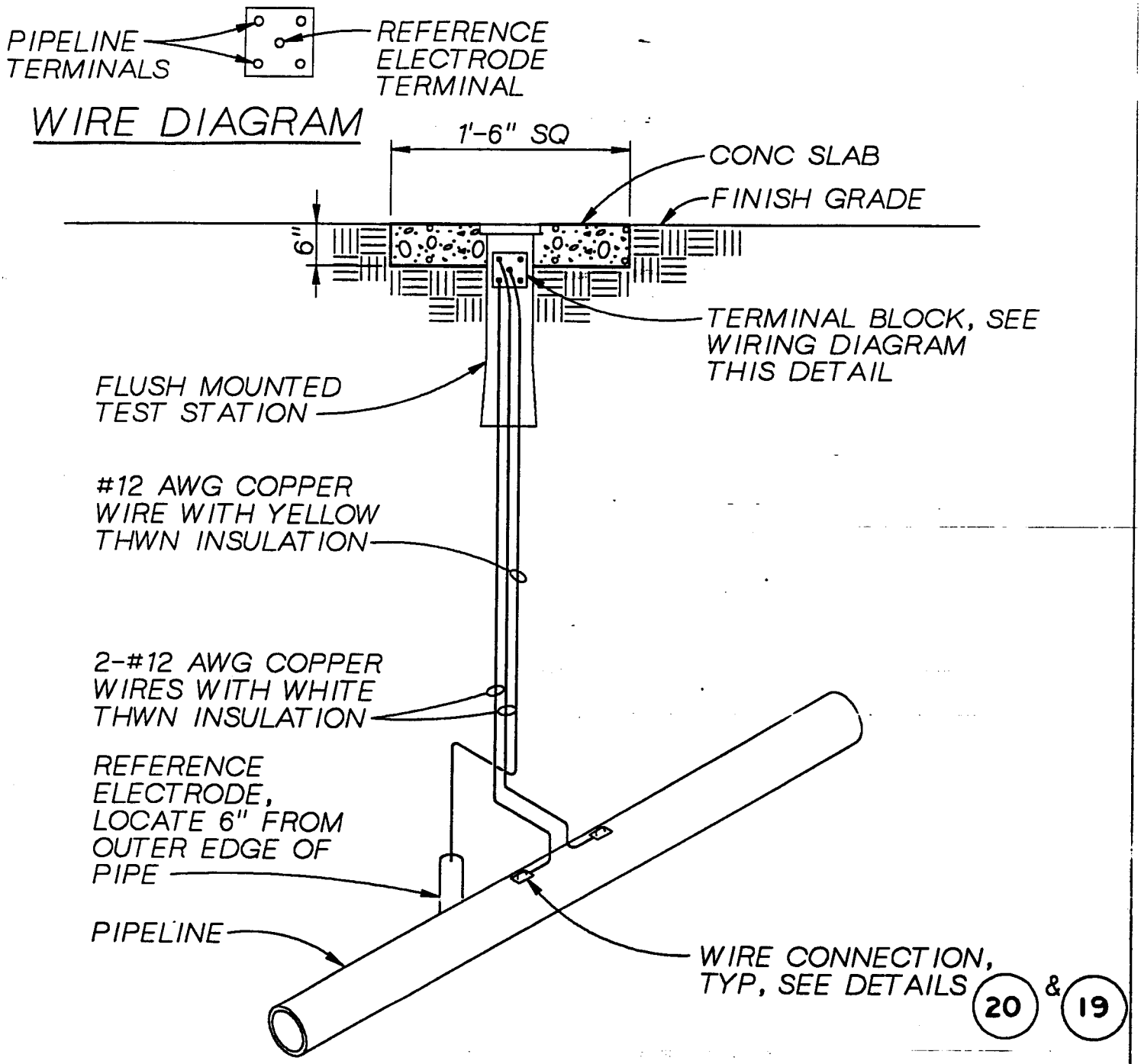
METHOD 2

NOTE:
INSTALL TWO BOND WIRES AT EACH PIPE JOINT ON 24 INCH OR LARGER

CONCRETE CYLINDER PIPE JOINT BOND

NTS

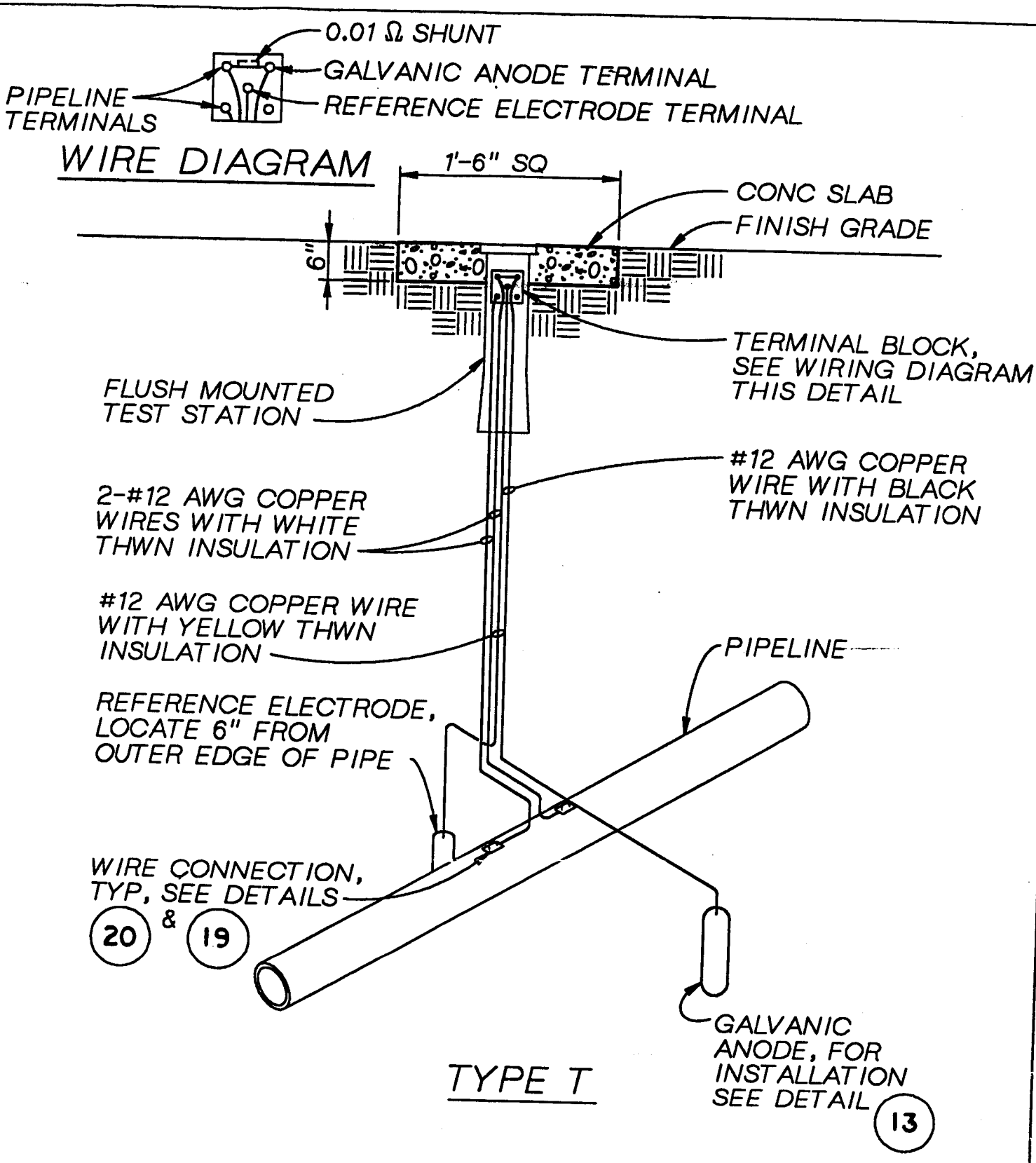
6



TYPE T

FLUSH MOUNTED TEST STATION 7

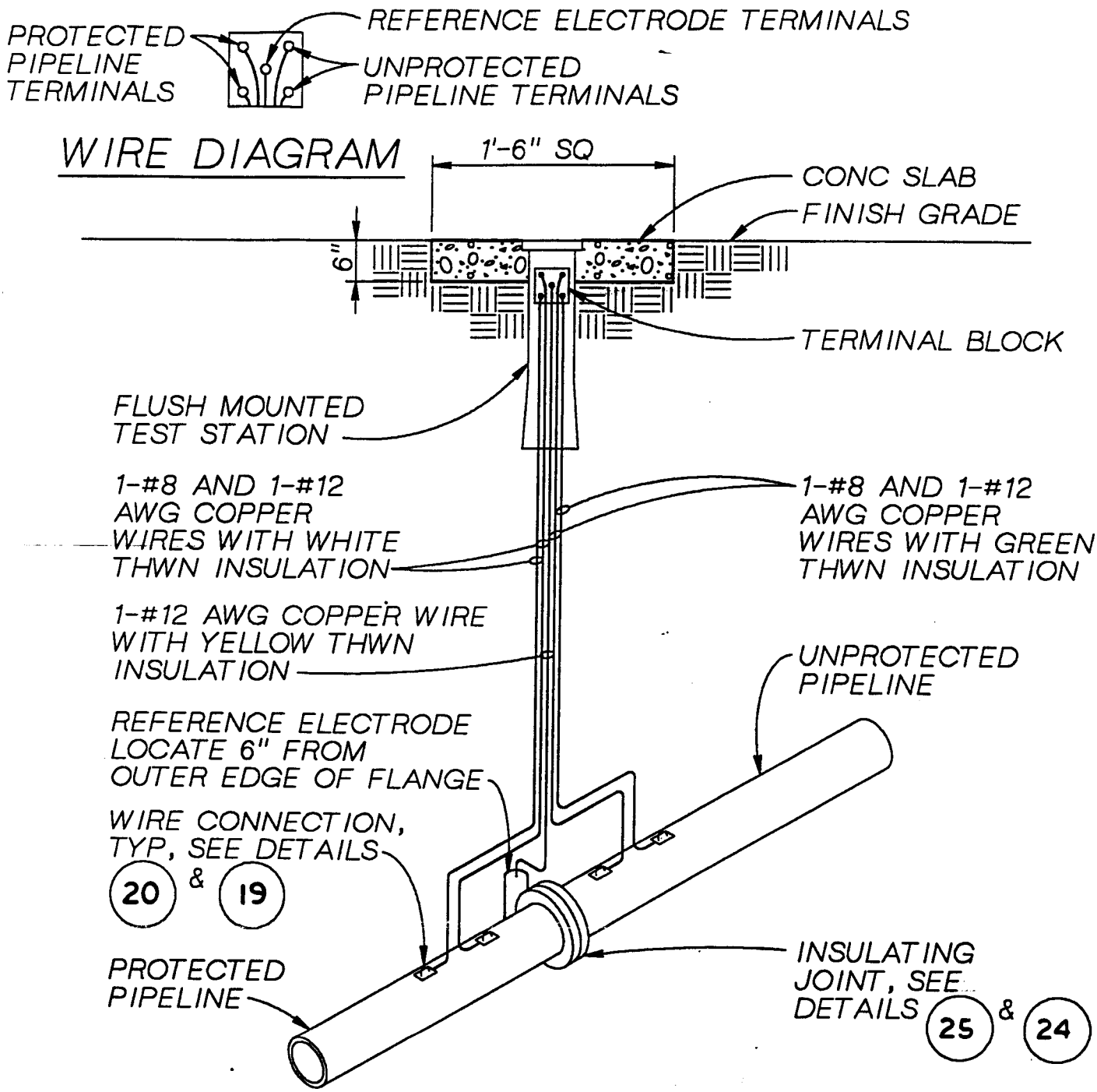
NTS



FLUSH MOUNTED TEST STATION

NTS

8

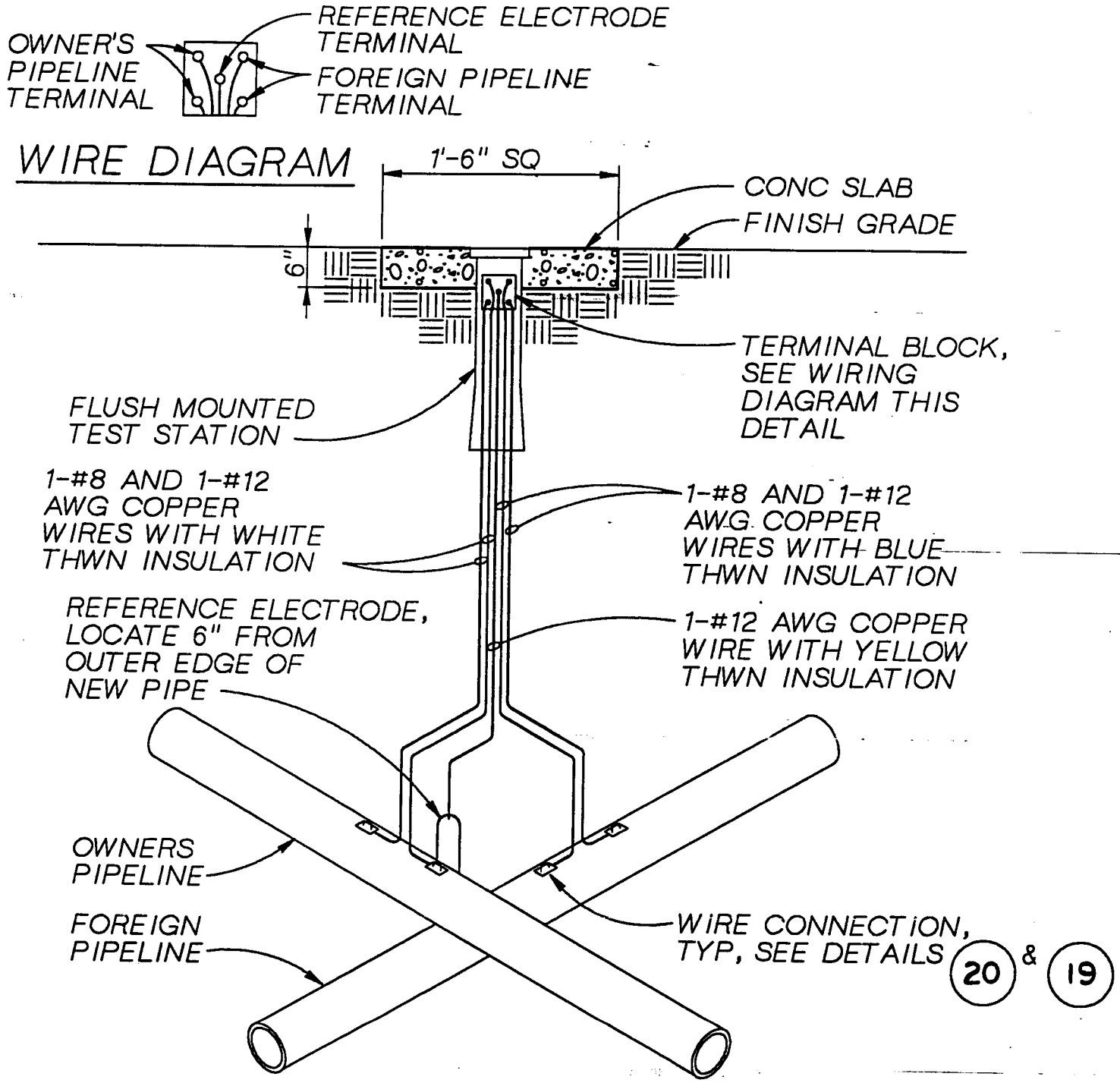


TYPE I

FLUSH MOUNTED TEST STATION

NTS

9



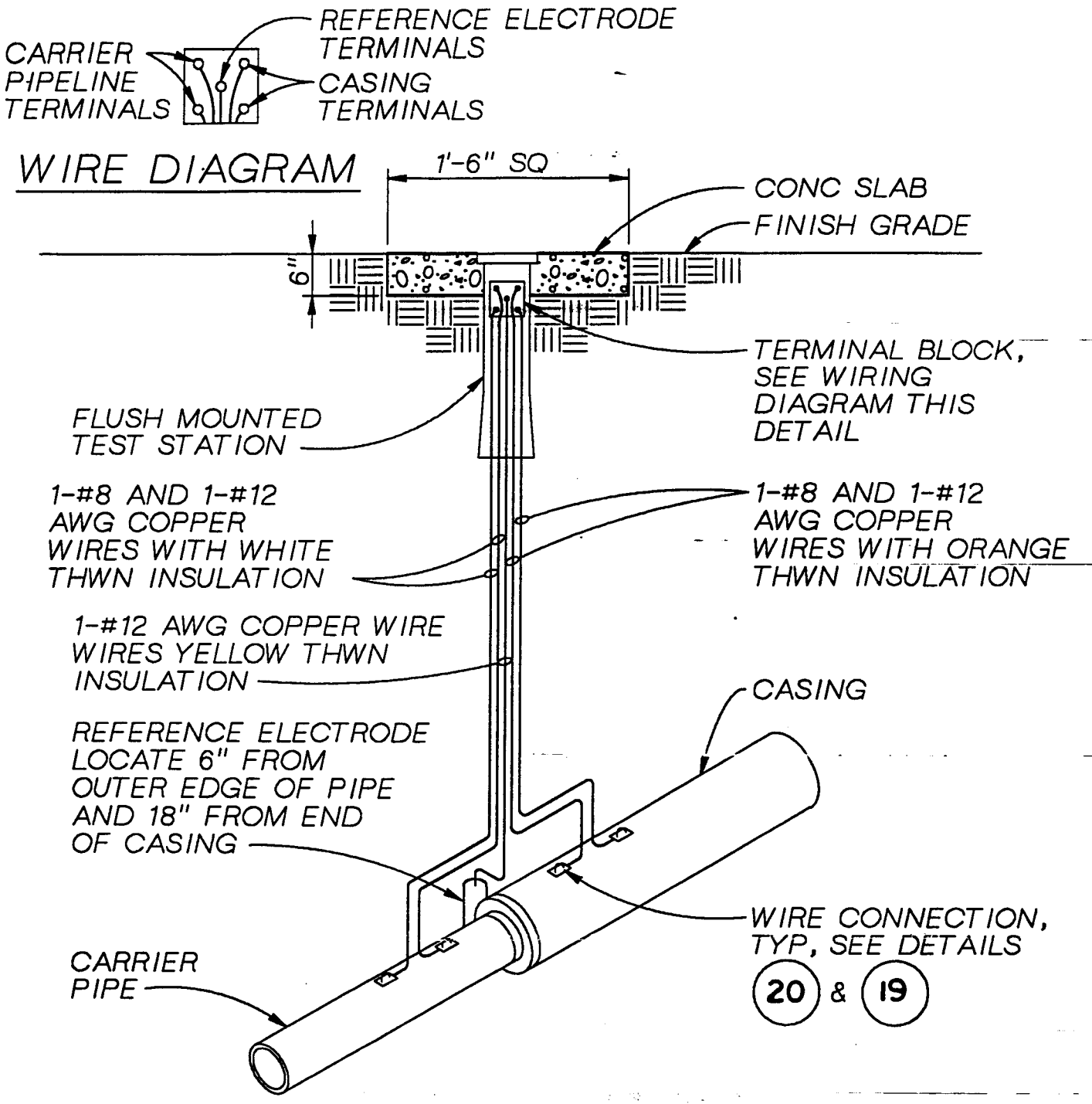
NOTE:
CONTACT FOREIGN PIPELINE OWNER PRIOR TO MAKING WIRE CONNECTIONS FOR APPROVAL.

TYPE F

FLUSH MOUNTED TEST STATION

NTS

10

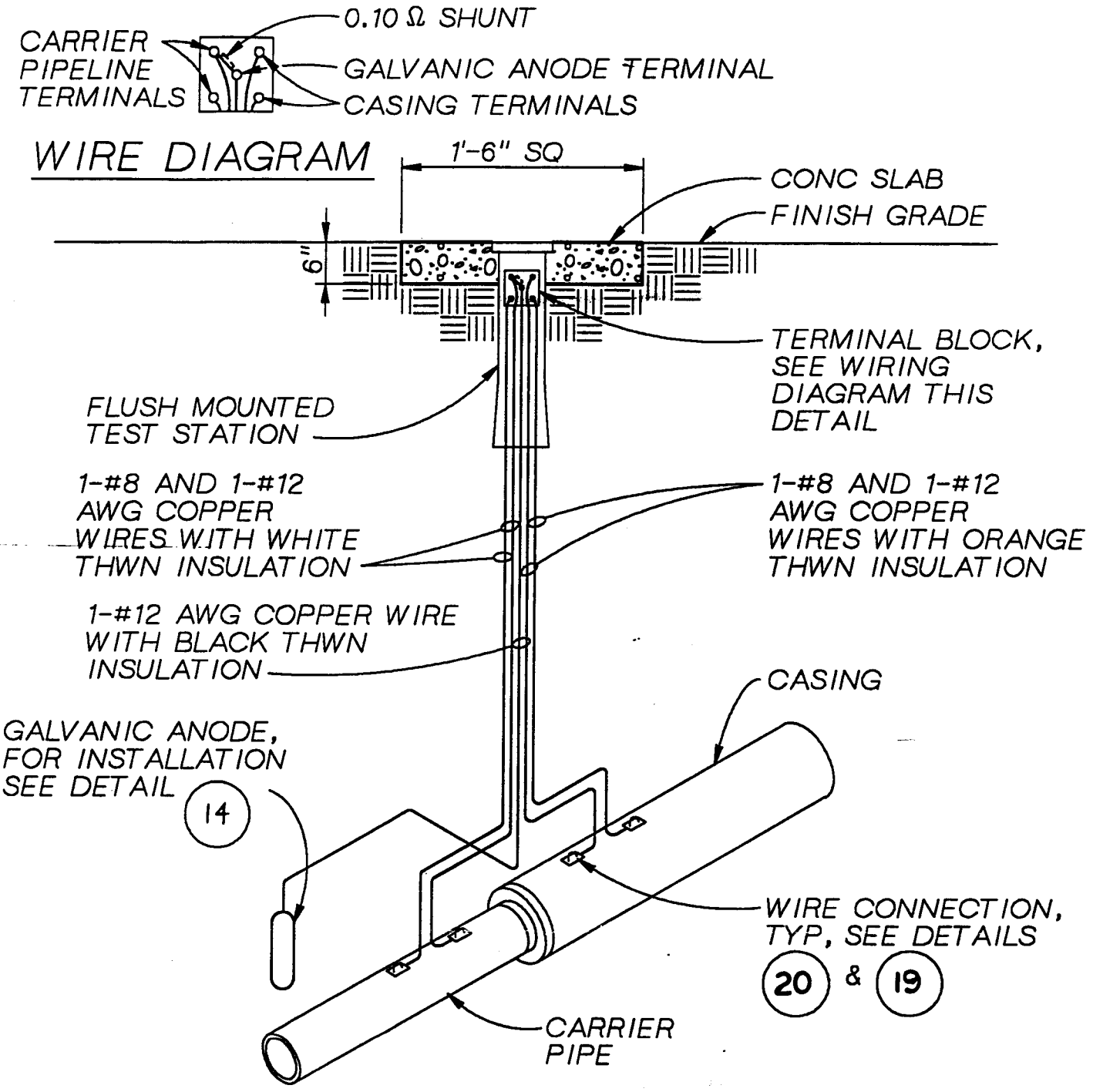


TYPE C

FLUSH MOUNTED TEST STATION

NTS

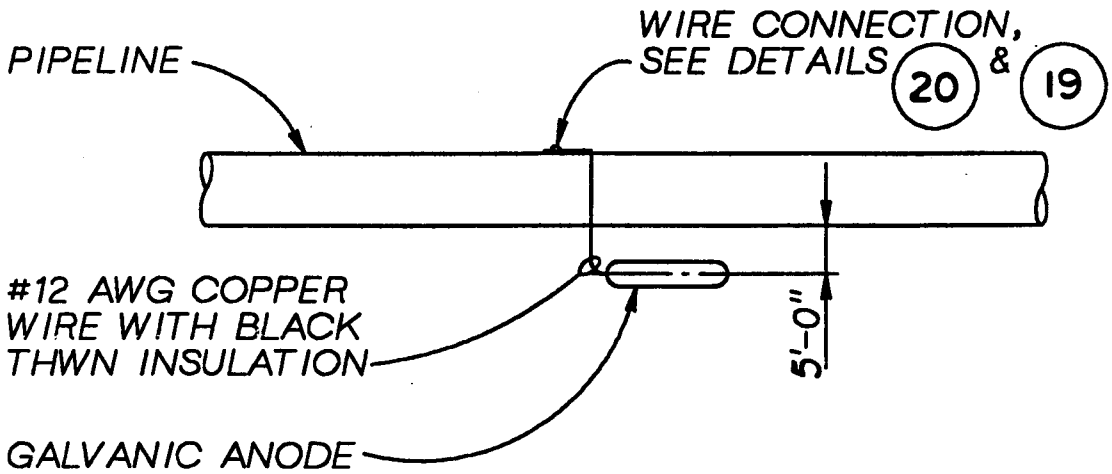
11



TYPE C

FLUSH MOUNTED TEST STATION 12

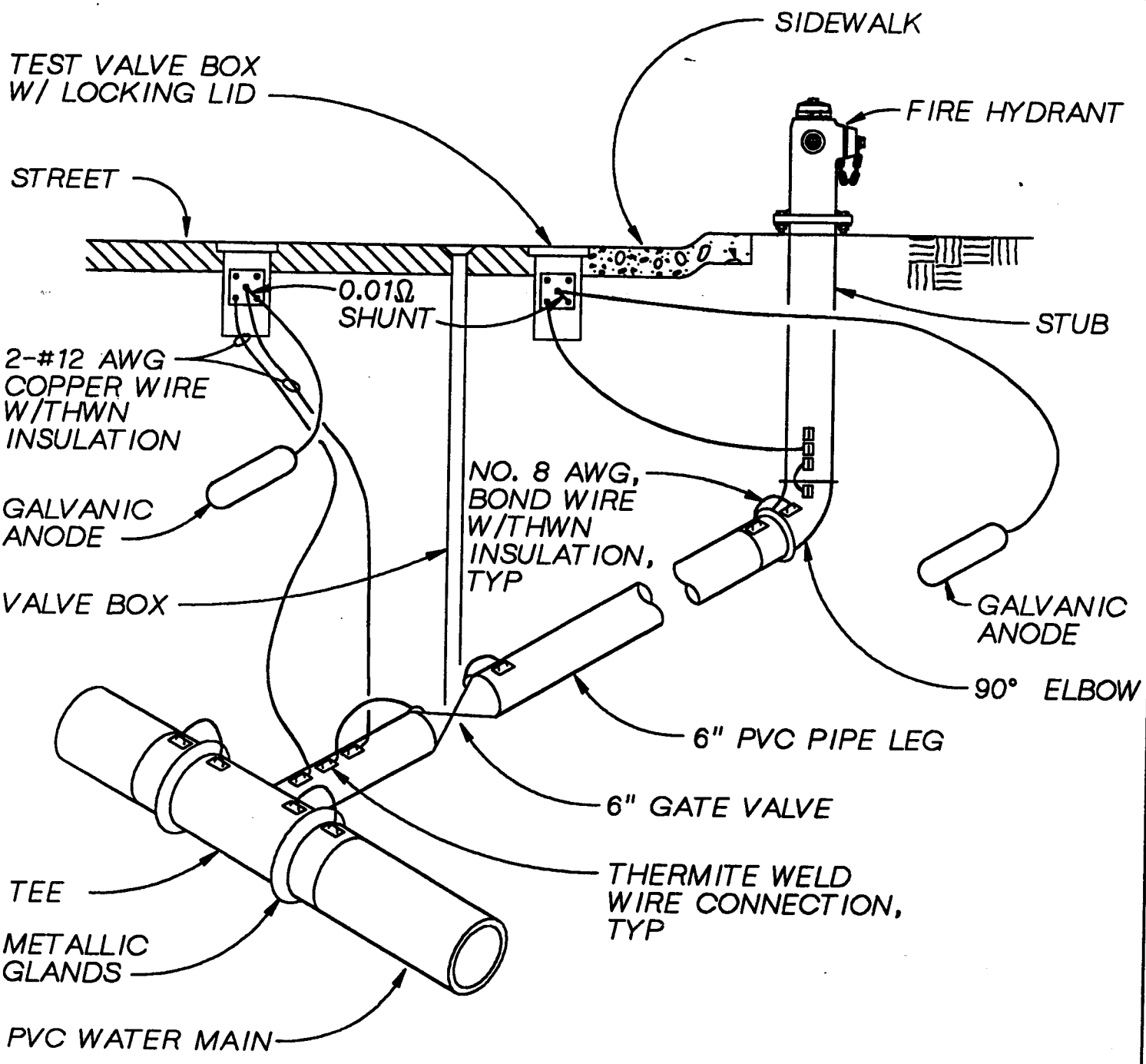
NTS



ELEVATION

GALVANIC ANODE INSTALLATION 13

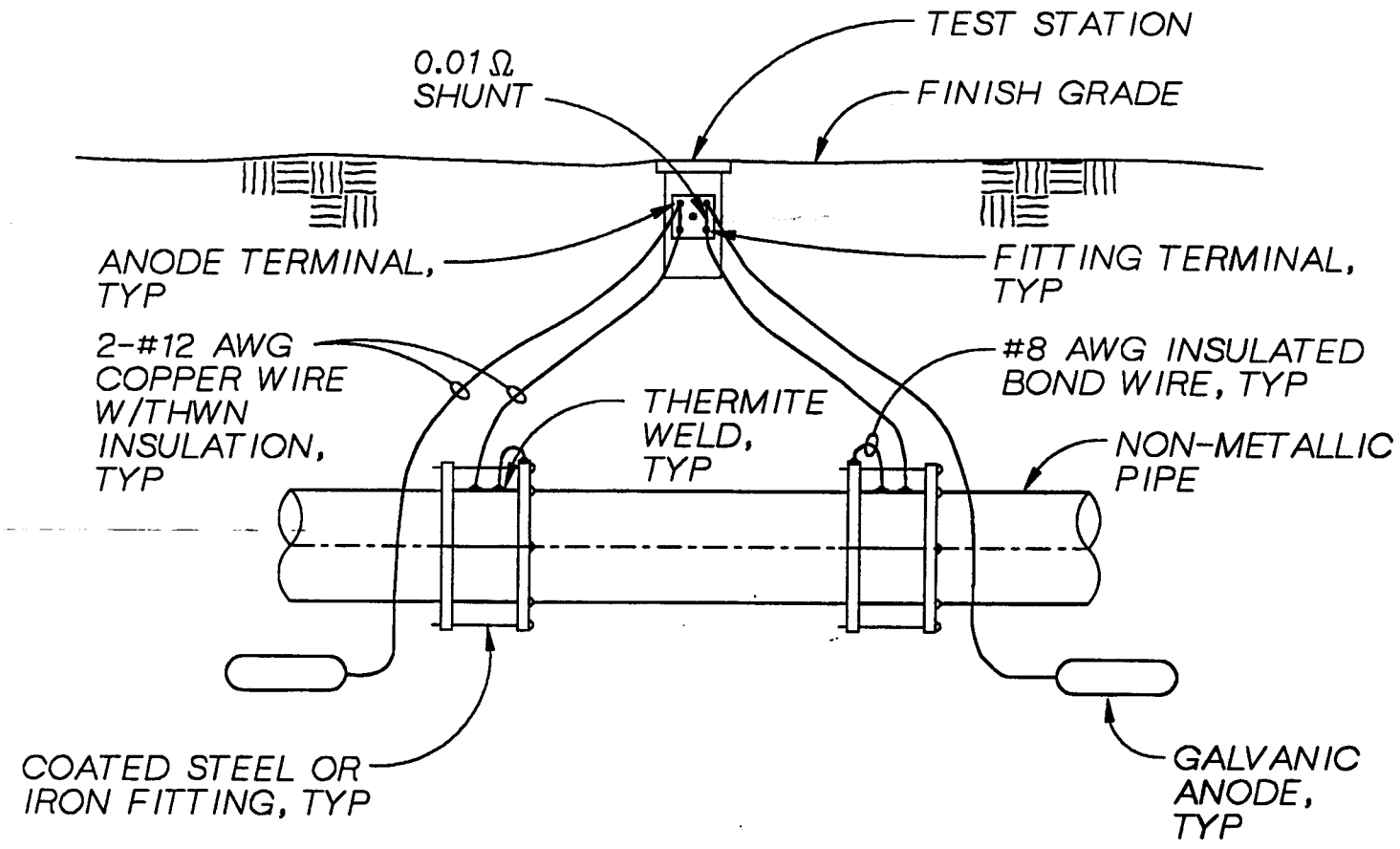
NTS



GALVANIC ANODE AT METALLIC FITTINGS FOR FIRE HYDRANT LOCATIONS ON PVC WATERMAINS

14

NTS

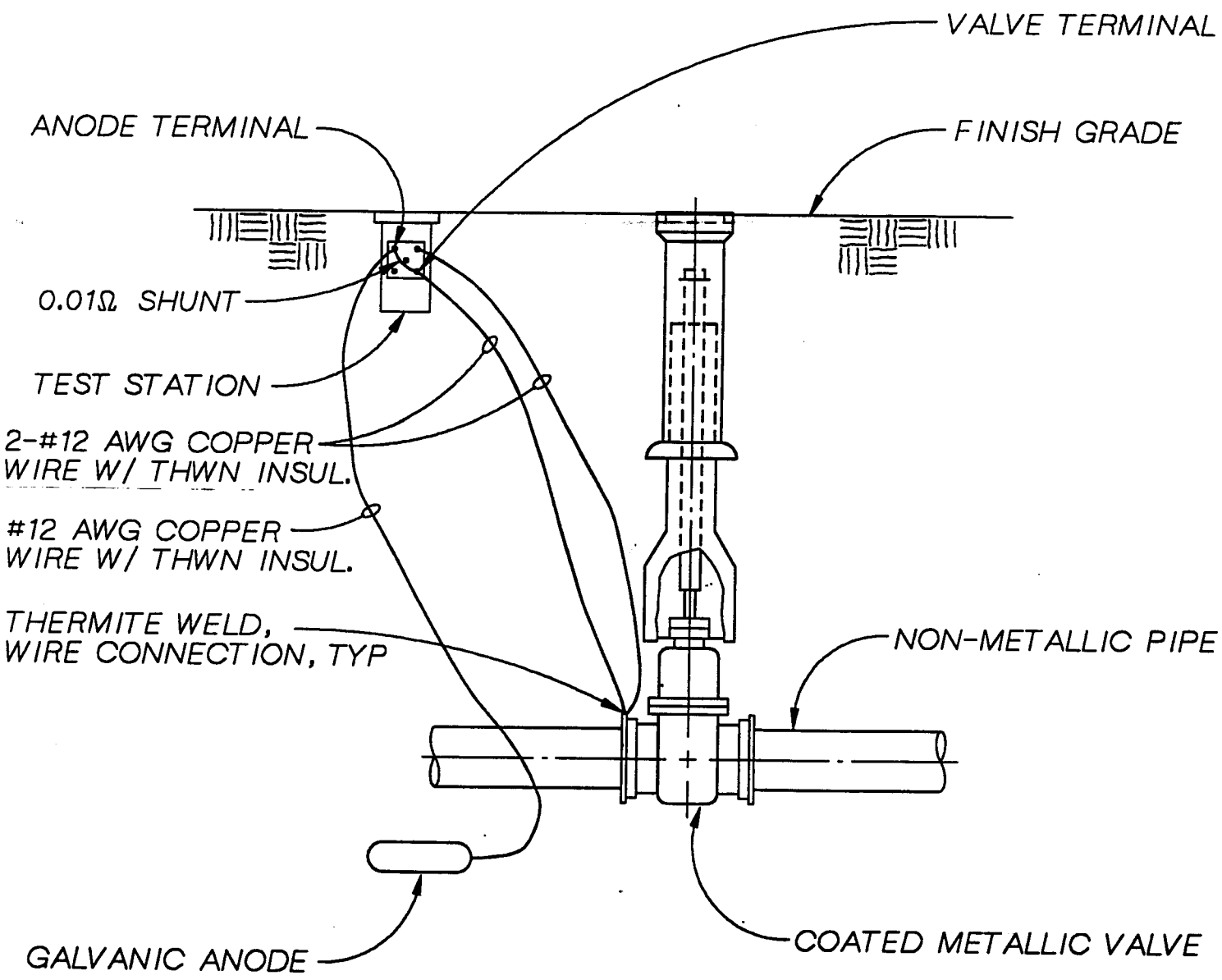


NOTE:
ANODE TOBE INSTALLED A MINIMUM OF 2 FEET FROM PIPE

TYPICAL GALVANIC ANODE AT FITTINGS (NON-METALLIC PIPE)

NTS

15

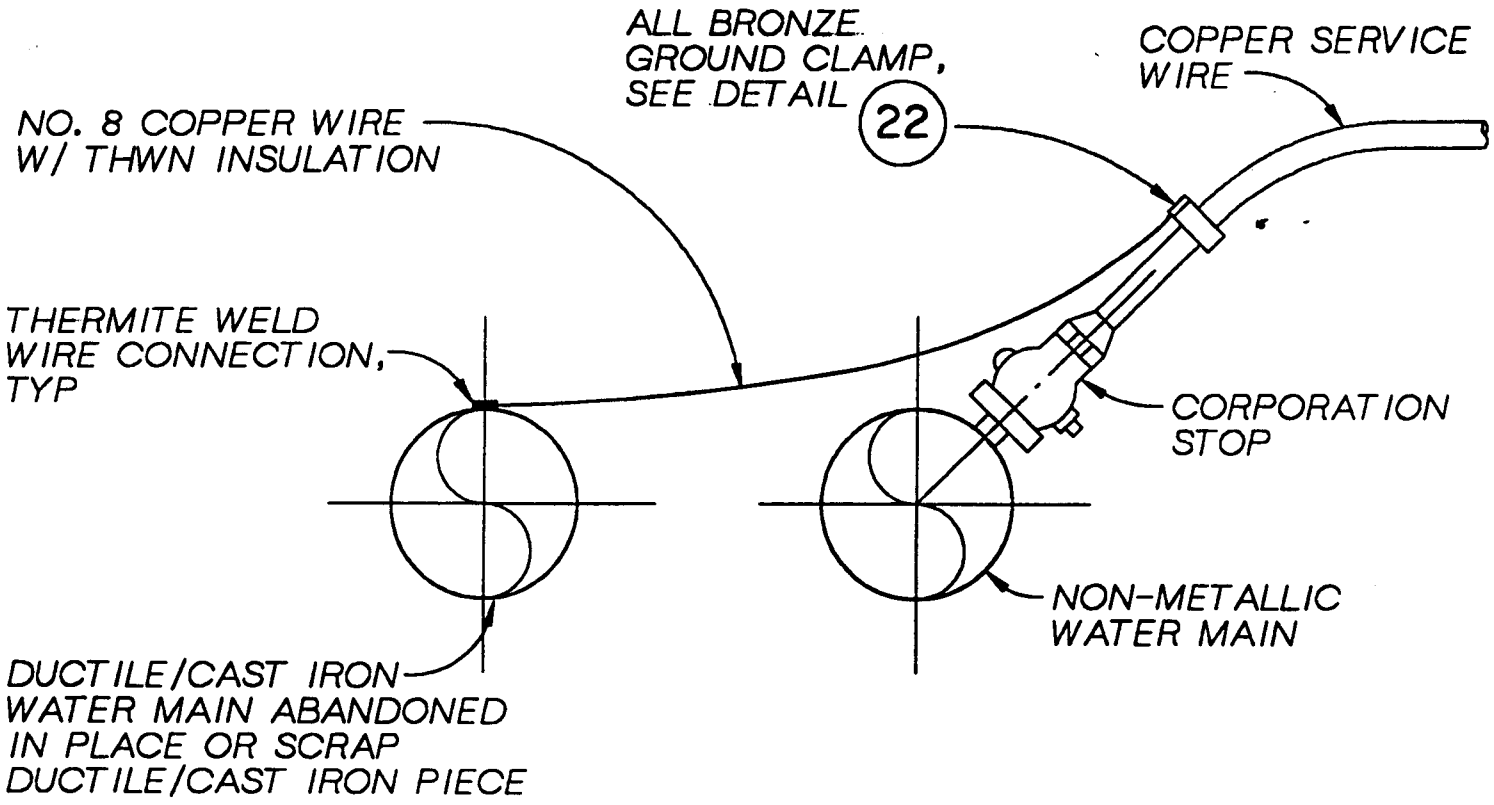


NOTE:
ANODE TOBE INSTALL A
MINIMUM OF 2 FEET FROM PIPE.

TYPICAL GALVANIC ANODE AT VALVE (NON-METALLIC PIPE)

NTS

16

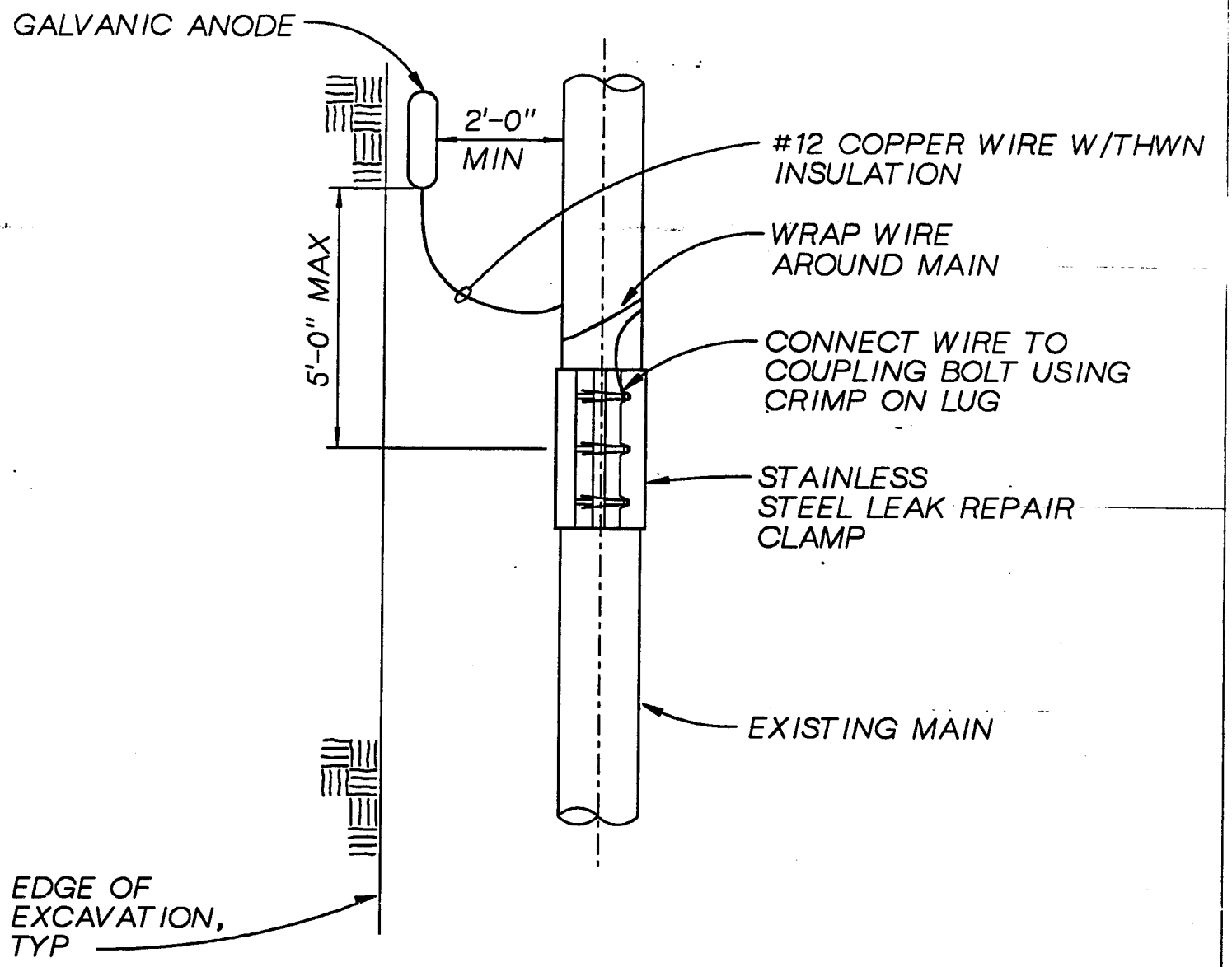


NOTE:
PIPE ANODE SHALL BE 6-INCH DIAMETER MINIMUM CAST OR DUCTILE IRON PIPE, 10-FOOT MINIMUM LENGTH.

DUCTILE OR CAST IRON PIPE ANODE (NON-METALLIC PIPE)

NTS

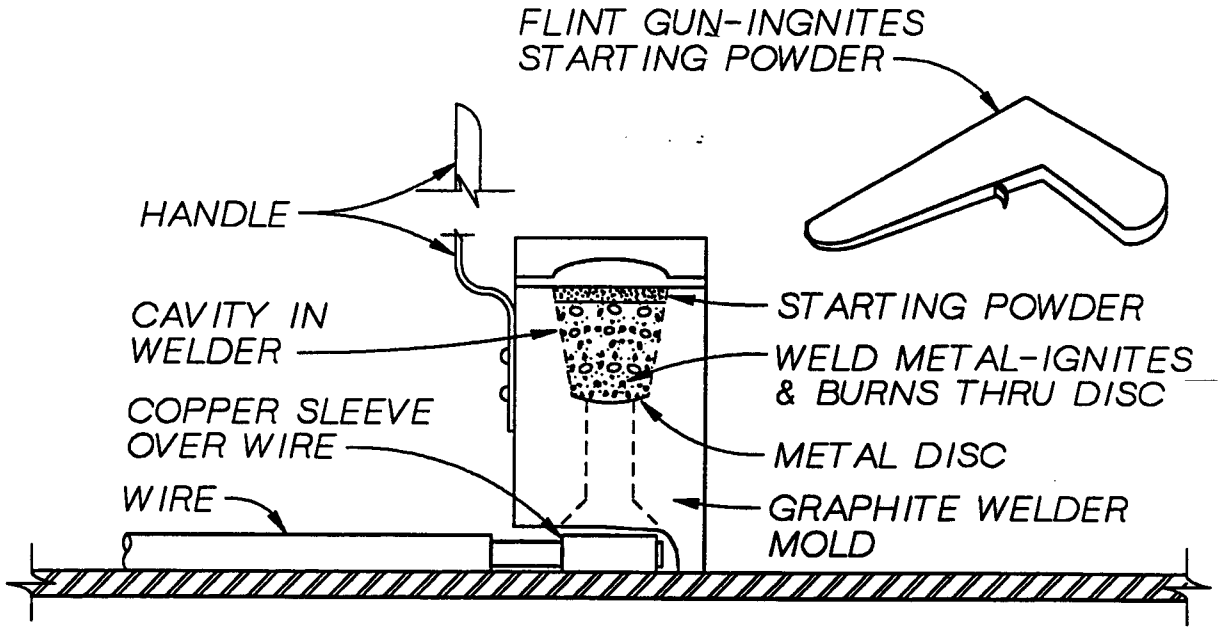
17



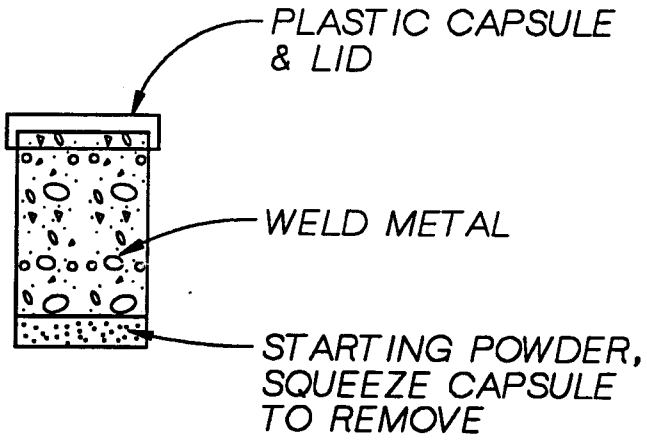
NOTES:
1. INSTALL ANODE AT APPROXIMATE PIPE DEPTH IN NATIVE SOIL.
2. MAXIMUM DISTANCE FROM ANODE TO LEAK REPAIR CLAMP IS 5 FEET.

GALVANIC ANODE AT LEAK REPAIR CLAMP

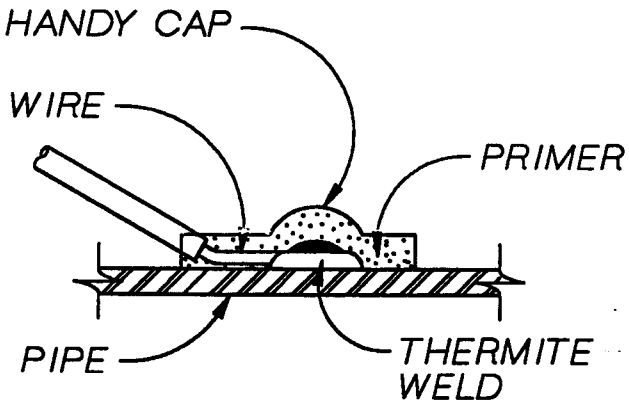
NTS



THERMITE WELD

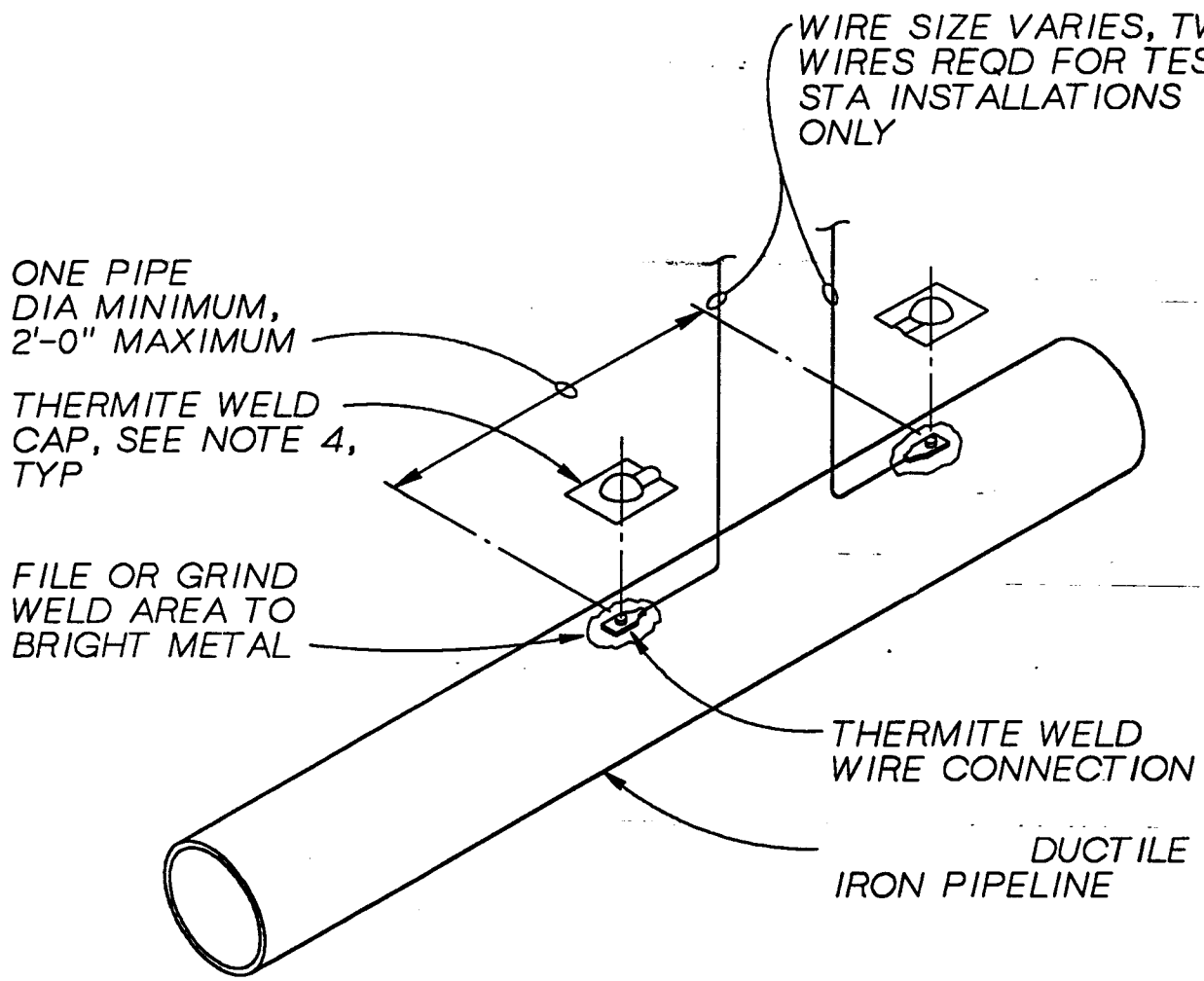


WELD METAL CAPSULE
(TYPE & SIZE VARIES)



FINISHED WELD
(WIRE BRAZED TO PIPE)

THERMITE WELD WIRE CONNECTION
NTS



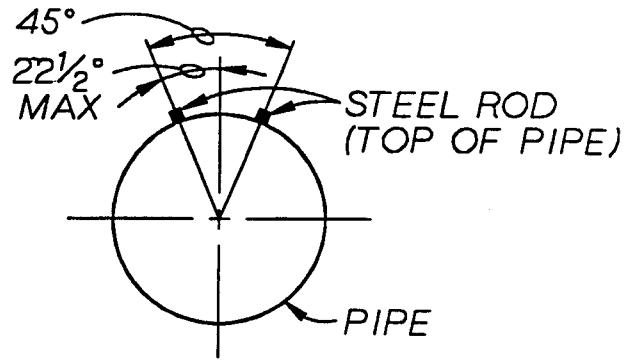
NOTES:

1. COPPER SLEEVE REQUIRED FOR THERMITE WELDING OF #10 AWG AND SMALLER WIRE.
2. USE COPPER SLEEVE ON #2 AWG JOINT BONDING WIRES.
3. WELDER AND CARTRIDGE SIZE VARIES ACCORDING TO WIRE SIZE AND PIPE MATERIAL, CONSULT WELDER MANUFACTURER FOR RECOMMENDED WELDER AND CARTRIDGE.
4. COAT WELD AREA AND FILL RECESS ON THERMITE WELD CAP WITH COLD APPLIED COAL TAR MASTIC AND APPLY CAP TO WELD.

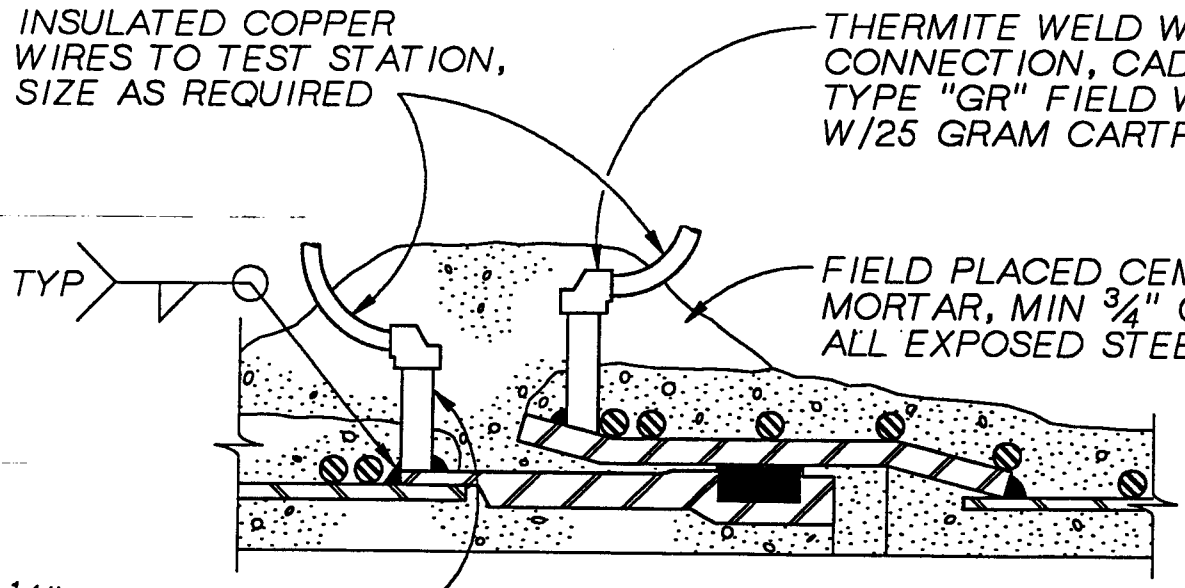
WIRE CONNECTION FOR DUCTILE IRON PIPE

NTS

20



DETAIL

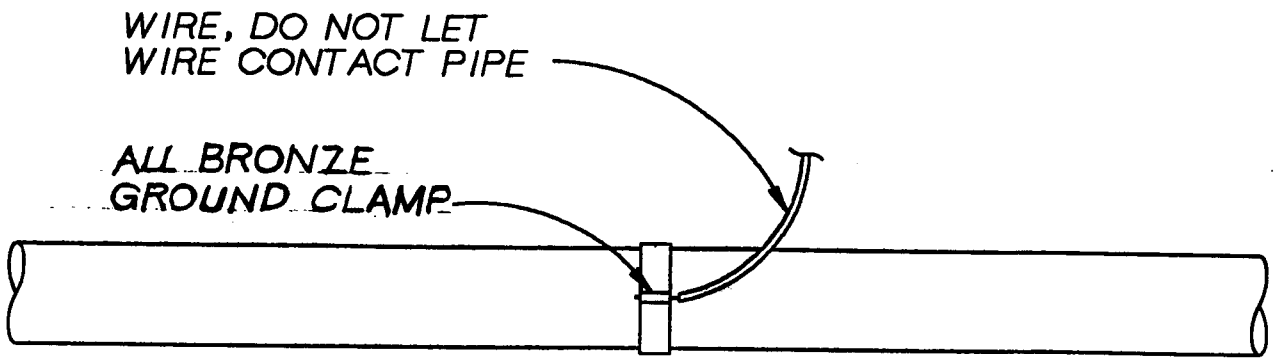


NOTE:
WELD STEEL RODS TO CYLINDER, 22½° MAX. FROM TOP OF PIPE ON ALTERNATE SIDES OF PIPE CIRCUMFERENCE, SPACING OF RODS TO BE 45° TOTAL.

CONCRETE CYLINDER PIPE TEST WIRE CONNECTION

NTS

21

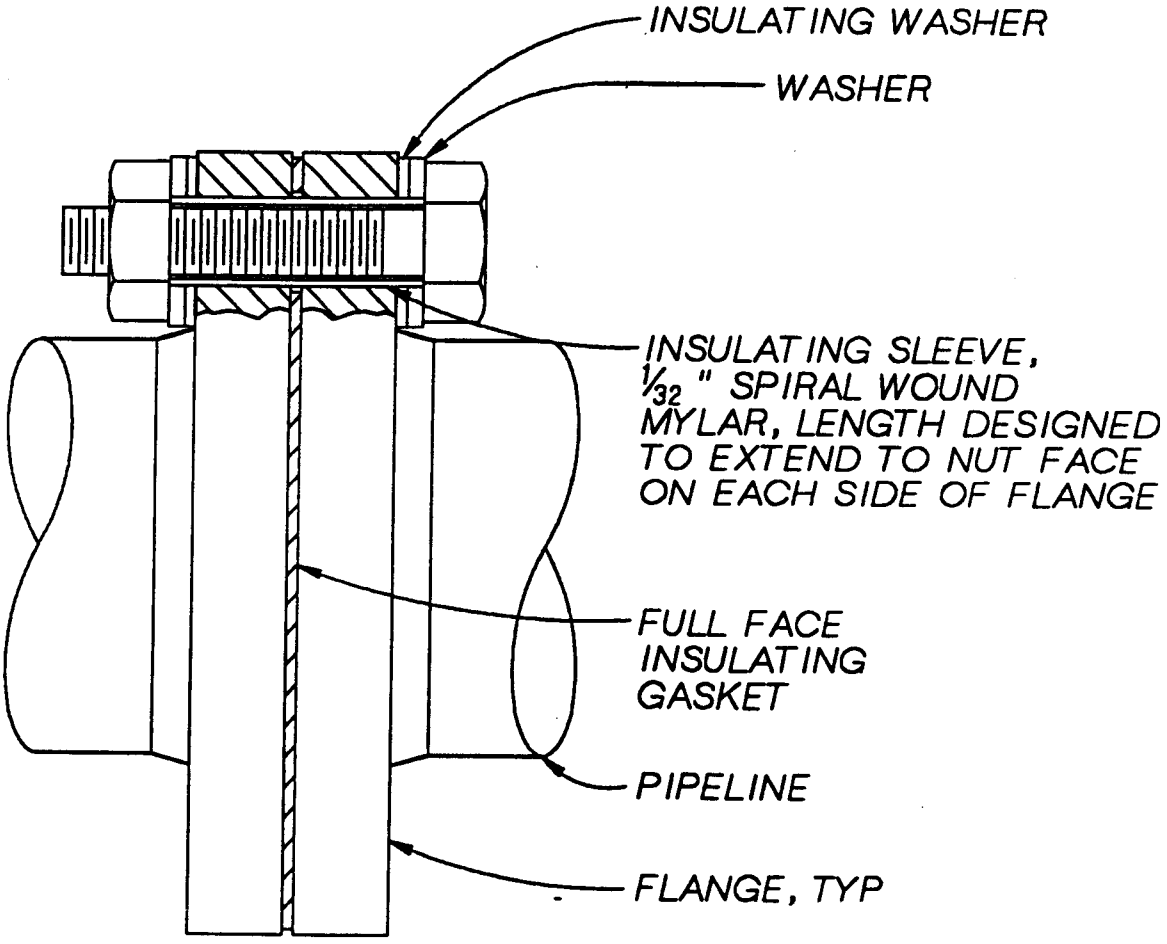


NOTE:

WIRE CONNECTION TO COPPER PIPE

NTS

22



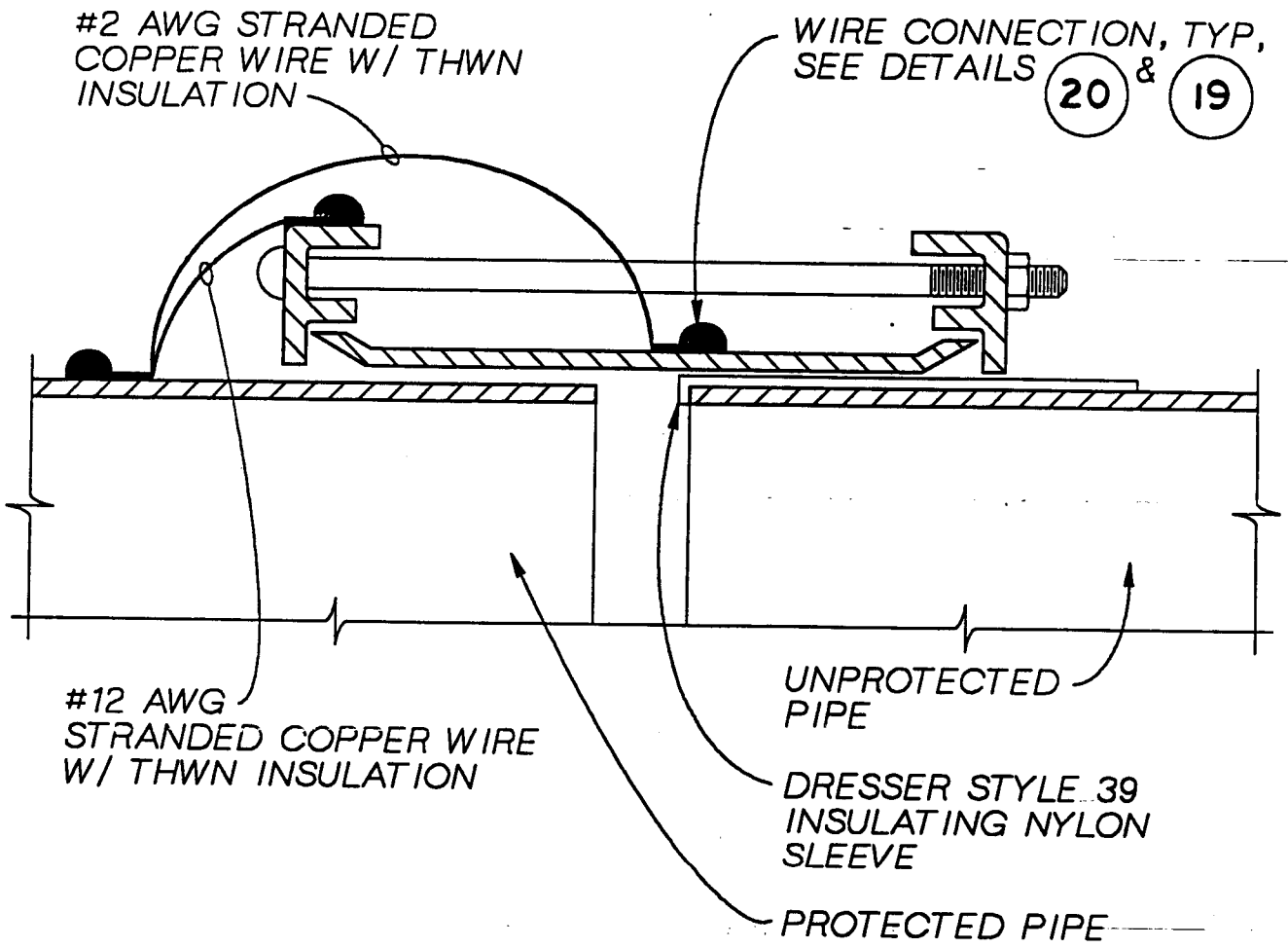
NOTES:

1. INSTALL INSULATING WASHER ON THE UNPROTECTED SIDE OF FLANGE.
2. COAT WITH COLD APPLIED COAL TAR MASTIC AFTER ASSEMBLING JOINT AND WRAP WITH A BUTYL RUBBER ADHESIVE, POLYETHYLENE BACKED TAPE.

INSULATING FLANGE

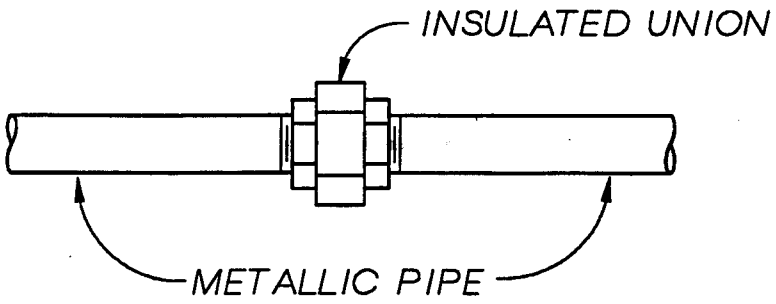
NTS

23



INSULATED FLEXIBLE COUPLING 24

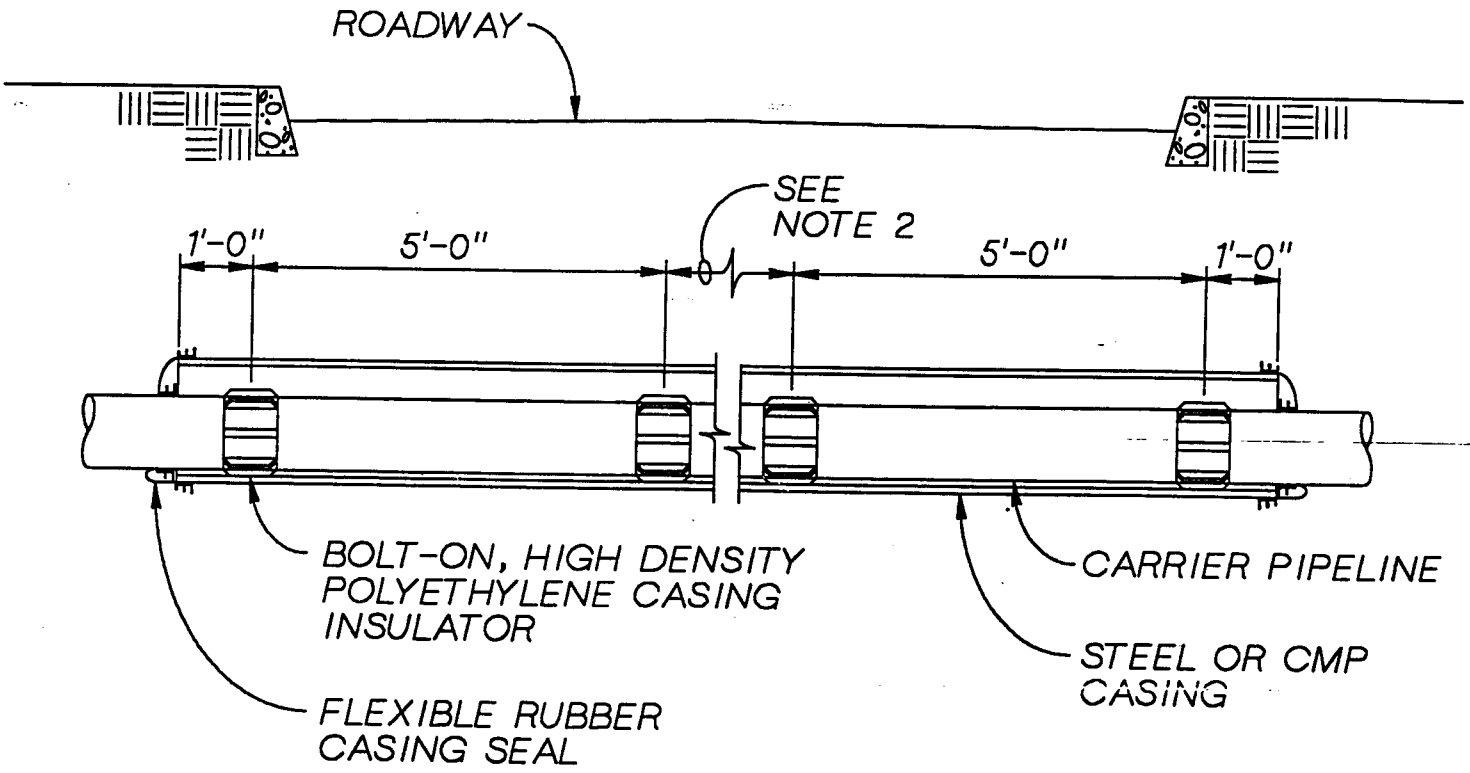
NTS



INSULATED UNION

NTS

25



NOTES:

1. CASING DIAMETER SHALL BE THE CARRIER PIPE DIAMETER PLUS 6" MAXIMUM.
2. SPACE ADDITIONAL INSULATORS AS NECESSARY AT 10'-0" INTERVALS, MAXIMUM.
3. INSTALL TYPE C TEST STATION ON CASING AND CARRIER PIPE, SEE DETAILS (12), (11)

CASED CROSSING

NTS

26

EXTERNAL CORROSION CONTROL
REVISIONS TO THE 1985
WATER SYSTEM STANDARDS
VOLUMES 1 AND 2

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU

1991

EXTERNAL CORROSION CONTROL
REVISIONS TO THE 1985 WATER SYSTEM STANDARDS VOL. 1
AND 1985 STANDARD DETAILS FOR WATER SYSTEM CONSTRUCTION VOL. 2

CONTENTS

Section 1
INTRODUCTION

TO ALL CONCERNED:

SUBJECT: REVISIONS TO THE 1985 WATER SYSTEM STANDARDS

The following sections 2 and 3 are revisions to the 1985 Water System Standards Volume 1, and 1985 Standard Details for Water System Construction Volume 2. The revisions are for the purpose of corrosion control and are intended for use on Oahu only. Refer to the 1991 Water System External Control Standards Volume 3 for additional requirements.

Section 2
REVISIONS TO 1985
WATER SYSTEM STANDARDS VOLUME 1

In order for the external corrosion control to work and to properly instruct to the project design engineers and/or contractors, some of the present Water System Specifications must be modified and/or sections added to them. These modifications and additions are described below.

TABLE 4, PAGE 5

- Due to the concern of asbestos fibers, change Table 4 to show that asbestos cement pipe is **not** allowed.
- Change a^{4} under ductile iron pipe to a^{8} and change a^{5} under concrete cylinder pipe $a^{5\&8}$.
- Add the following note to Table 4:

  a^{8}--see Volume 3 for external corrosion control requirements.

SECTION 1.2.5, PAGE 6

Add the following after the first paragraph on top of page:

- For Oahu Only: If the water line is cathodically protected or set up for future cathodic protection, it shall be electrically isolated from the bridge, pier, or other structures.

SECTION 1.2.9, PAGE 10

Add the following:

- **1.2.9.1 Corrosion Protection (Oahu only):** Corrosion protection is required for all buried metallic pipe, appurtenances, fittings, etc. Soil resistivity tests are required in all cases. The types of corrosion protection will be determined by the soil resistivity. If concrete-coated pipe is to be used, soil samples must be obtained and soil analyses performed (pH, chlorides, and sulfates) in addition to the soil resistivity. The test results shall be submitted as part of the project design. See Volume 3 of the Water Systems Standards for the appropriate corrosion protection. The corrosion protection design shall be approved by the Manager.

SECTION 1.4.2, PAGE 16

Add the following to item e.

- 5. For Oahu Only: See Volume 3 for required corrosion protection and electrical isolation requirements.

SECTION 2.12, PAGE 23

Add the following:

- **Section 2.12 Corrosion Protection (Oahu only):** Corrosion protection shall be provided for buried lines as specified in Volume 3 of the Water Systems Standards. Steel reservoirs and submerged metallic structures in concrete reservoirs shall have corrosion protection, such as adequate coatings, etc. The corrosion protection design shall be approved by the Manager.

SECTION 2.1, PAGE 44

Add to the bottom of page, before Table 19

- For Oahu only: See Volume 3 for required coating types and other corrosion control requirements.

SECTION 2.1, PAGE 46

Add the following after paragraph on **Exterior Coatings**:

- **For Oahu only**, see Volume 3 for additional external corrosion control requirements.

SECTION 2.3, PAGE 47

Add the following to item A, after paragraph on bolts and nuts.

- For Oahu only: Silicon bronze (ASTM F467 and F468) or stainless steel (ASTM F738) bolts and nuts shall be used for all mechanical joints.

SECTION 2.5, PAGE 48

Add after paragraph, **For Hawaii only**:

- **For Oahu only**, silicon bronze (ASTM F467 and F468) or stainless steel (ASTM F738) bolts and nuts shall be used for all flanged joints installed underground.

SECTION 3.1, PAGE 50

Add the following:

- H. **Corrosion Protection (Oahu only).** See Volume 3 for additional corrosion control requirements.

SECTION 3.2, PAGE 51

Add to Section B:

- For Oahu only: A sulfate-resistant cement and/or high build epoxy coating may be required in certain areas. See Volume 3 for requirements.

Also add:

- D. For Oahu only: Electrical continuity plates or straps are required. See Volume 3 for requirements.

SECTION 3.3, PAGE 53

Add the following to Section B:

- 5. For Oahu only: Electrical continuity plates or straps are required. See Volume 3 for requirements.

Also add the following:

- D. **For Oahu only.** A sulfate-resistant cement and/or high build epoxy coating may be required in certain areas. See Volume 3 for requirements.

SECTION 5, PAGE 56

Add the following after the bottom paragraph

- **For Oahu only.** All fittings shall be supplied with a fusion-bonded coating and cathodically protected as specified in Volume 3.

SECTION 6.1, PAGE 58

Add the following after first paragraph in Item A:

- For Oahu only: See Volume 3 for required coating.

Under Item A where it says the following requirement applies to Hawaii only, it should be changed:

- The following requirement applies to Hawaii and Oahu only

SECTION 6.1, PAGE 59

The following after first paragraph in Item C:

- For Oahu only: See Volume 3 for required coating.

SECTION 6.2, PAGE 59

Add the following after first paragraph in Item A:

- For Oahu only: See Volume 3 for required coating.

SECTION 6.3, PAGE 60

Add the following after third paragraph:

- For Oahu only: See Volume 3 for required coating.

SECTION 6.5, PAGE 61

Add the following after the fifth paragraph:

- For Oahu only: See Volume 3 for required coating.

SECTION 7.1, PAGE 63

Add before section 7.2:

- **The following requirement applied to Oahu only**: Fire hydrants coatings shall be 3 mils dry each coat, and be provided with bolts and nuts made of silicon bronze (ASTM C655 or C651) or stainless steel (ASTM 300 series). The break-off bolts and nuts shall be heavy stainless steel drilled as previously described.

SECTION 9.1 AND 9.2, PAGE 67

Add before 9.2 and also before 9.3:

- **For Oahu only**: see Volume 3 for additional corrosion control requirements.

SECTION 10.2, PAGE 74

Add before 10.3:

- **For Oahu only**: The pipe cushioning material shall have a resistivity of 5,000

ohm-cm or greater when saturated with distilled water and measured using the soil box method explained in ASTM standard G-57 found in Volume 3.

SECTION 1.12.3, PAGE 98

Add the following to the second paragraph:

- For Oahu only: During installation, the pipes and appurtenances shall be handled only with slings cushioned along the areas coming in contact with the pipe or appurtenances to protect the pipe coating. The coating shall be inspected and repaired as specified in Volume 3.

SECTION 1.12.3, PAGE 99, ABOVE ITEM A.

Add the following:

- **For Oahu only.** Joint bonds may be required. See Volume 3 for all requirements including testing.

SECTION PAYMENT, PAGE 102

Add the following after the last paragraph:

- For Oahu only: The Unit Price Bids shall include corrosion control items.

SECTION 1.12.4, PAGE 102

Add the following after the bottom paragraph:

- For Oahu only: The coating shall be inspected and repaired as specified in Volume 3.

SECTION 1.12.4, PAGE 103

Add after the 6th paragraph:

- **For Oahu only.** Joint bonds are required in all areas that cement-coated pipe are installed. See Volume 3 for all requirements including testing.

SECTION 1.12.5, PAGE 106

Add the following after the second paragraph:

- For Oahu only: The conductive cable shall not be tied to or in contact with the gate valves or any other metallic fitting. The wire ends to be terminated in a valve box, meter box, or manhole as detailed in Volume 3.

Add the following after the third paragraph:

- For Oahu only: Whenever the cable is required to be jointed it shall be done mechanically using a split-bolt connector and/or soldered and taped. The conductive cable shall not contact the gate valves or any other metallic appurtenance or fitting.

SECTION 1.12.9, PAGE 111

Add to the bottom of the page:

- **For Oahu only.** See Volume 3 for the corrosion control requirements for copper services.

SECTION 1.12.9, PAGE 112

Add the following to the end of Item B.1:

- For Oahu only: The conductive cable shall not be tied to or in contact with the corporation stops, stop cock, or any other metallic fitting. The ends shall be terminated inside a test box and/or meter box (see volume 3).

SECTION 1.12.29, PAGE 129

Add:above Payment

- **For Oahu only.** See Volume 3 for the required corrosion control protection and testing of these items.

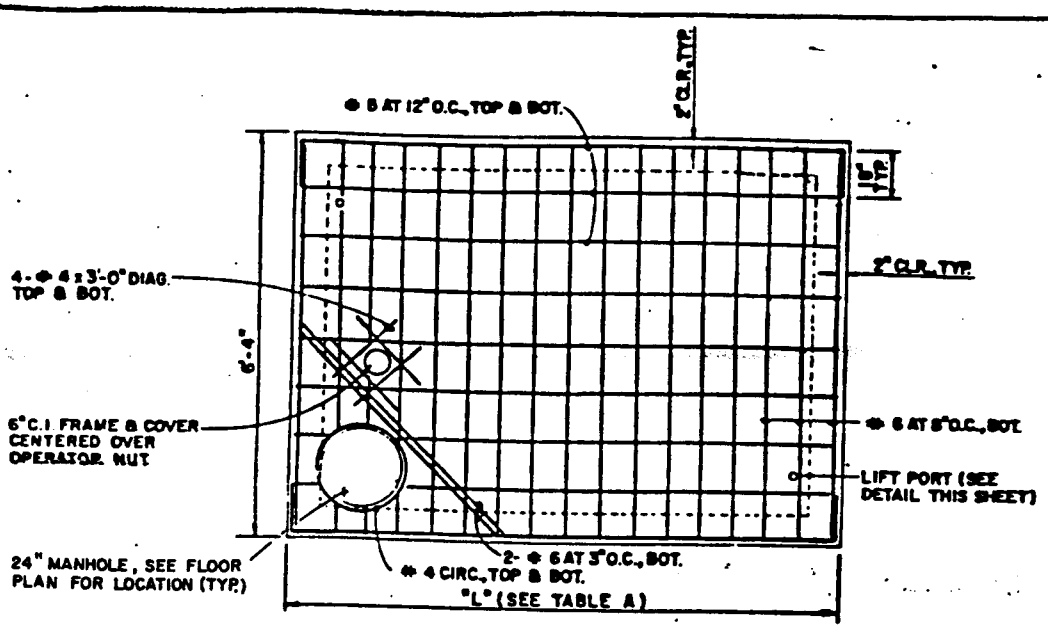
SECTION 1.12.32, PAGE 130

Add the following after section 1.12.31:

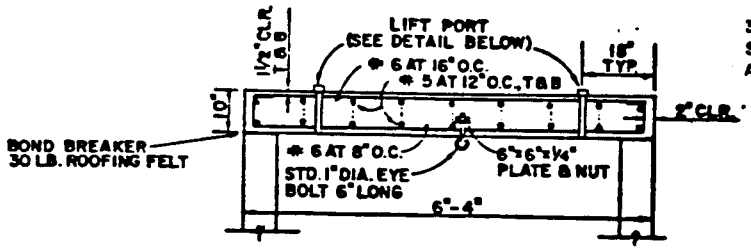
- 1.12.32 **For Oahu only.** All corrosion control items must be tested before acceptance of the pipeline. See Volume 3 for required testing procedures. Test results shall be submitted to the Manager for approval.

Section 3
REVISIONS TO 1985
STANDARD DETAILS FOR WATER SYSTEM CONSTRUCTION VOLUME 2

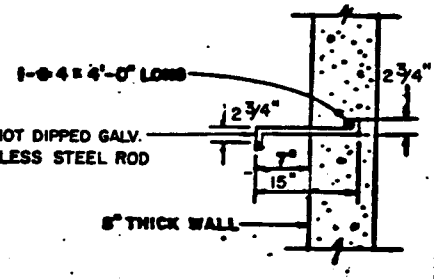
In order for the external corrosion control to work and to properly instruct the project design engineers and contractors, some of the present Water System Standard Details must be revised and notes added to them. Revised copies of these details are included in this section with the notes (in boxes).



ROOF SLAB PLAN

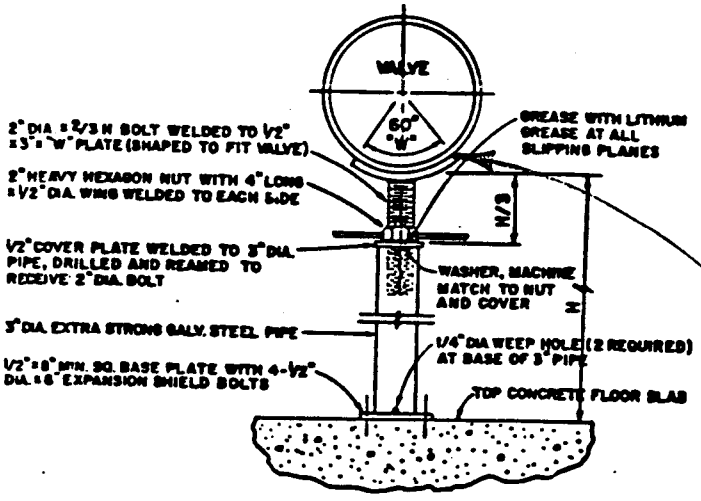


ROOF SLAB SECTION



RUNG DETAIL

NOTE: HEIGHT (H) TO BE DETERMINED IN FIELD PRIOR TO FABRICATION.



VALVE SUPPORT DETAIL

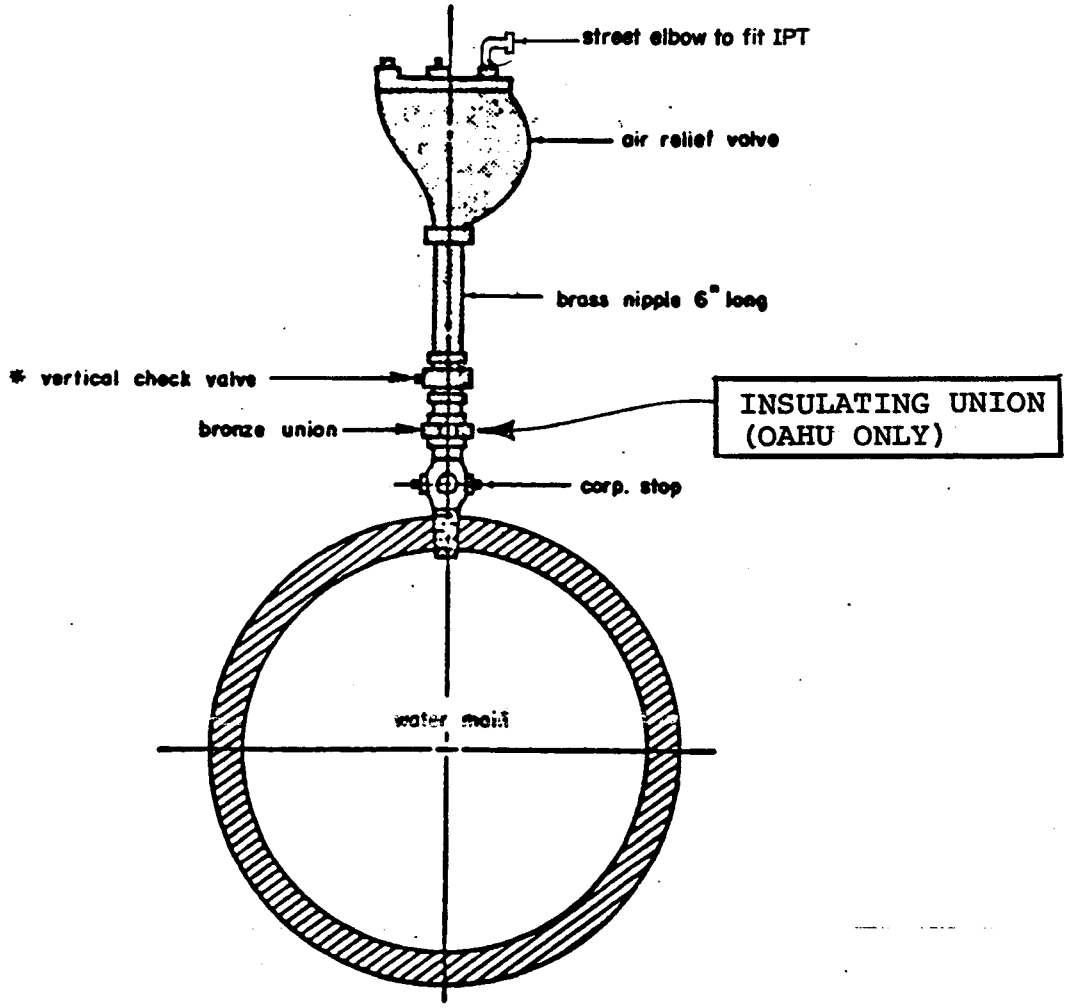
NOTES:

1. ALL CONCRETE FOR MANHOLE SHALL BE DWS 3500.
2. PAINT ALL METAL ITEMS:
   A. MANHOLE FRAME & COVER, AND VALVE WITH ASPHALTUM.
   B. VALVE SUPPORT AND RUNGS.
   C. SEE PAINTING SECTION OF SPECIFICATIONS FOR PAINT TYPE, SURFACE PREPARATION, ETC.
3. VALVE SUPPORT SHALL BE HOT DIPPED GALVANIZED AFTER FABRICATION.
4. M.H. DESIGNED FOR H20 LOADING.

INSTALL 1/8" THICK SHEET GASKET BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)

1991
1985
REVISION

KAUAI OAHU MAUI HAWAII	REINFORCED CONCRETE TYPE A MANHOLE MISCELLANEOUS DETAILS SCALE: NTS	STANDARD DETAILS	4



STANDARD CONNECTION FOR AIR RELIEF VALVE

NOTE

For 2" air relief valve, size of corp. stop shall be 1½" x 2". Union, vertical check valve and nipple shall be 2".

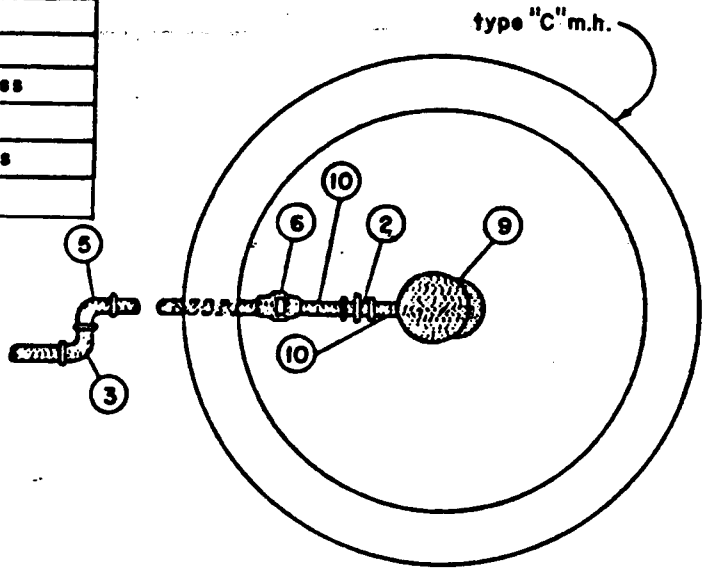
* Vertical check valve required when air relief valve is immersed in water.

1991
1985
REVISION

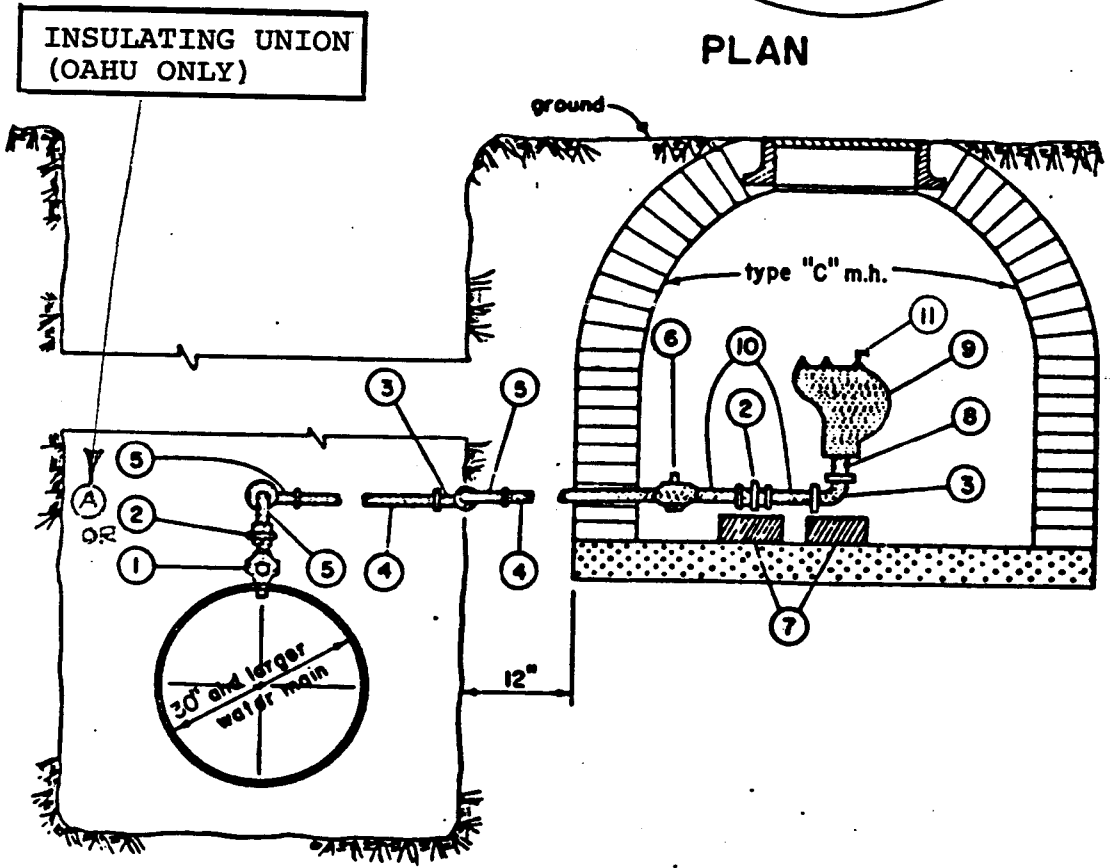
OAHU MAUI	**AIR RELIEF VALVE CONNECTION IN MANHOLE** SCALE : NTS	STANDARD DETAILS	**23**

LIST OF MATERIALS

ITEM	NO. REQ.	DESCRIPTION
1	1	1½" x 2" corporation stop
2	2	2" union, bronze
3	3	2" 90 elbow, bronze
4	2	2" brass pipe, cut to fit
5	3	2" street elbow
6	1	2" stop cock
7	2	Brick support
8	1	2" dia. x 4" nipple, brass
9	1	2" air relief valve
10	2	2" dia. x 6" nipple, brass
11	1	street elbow to fit IPT



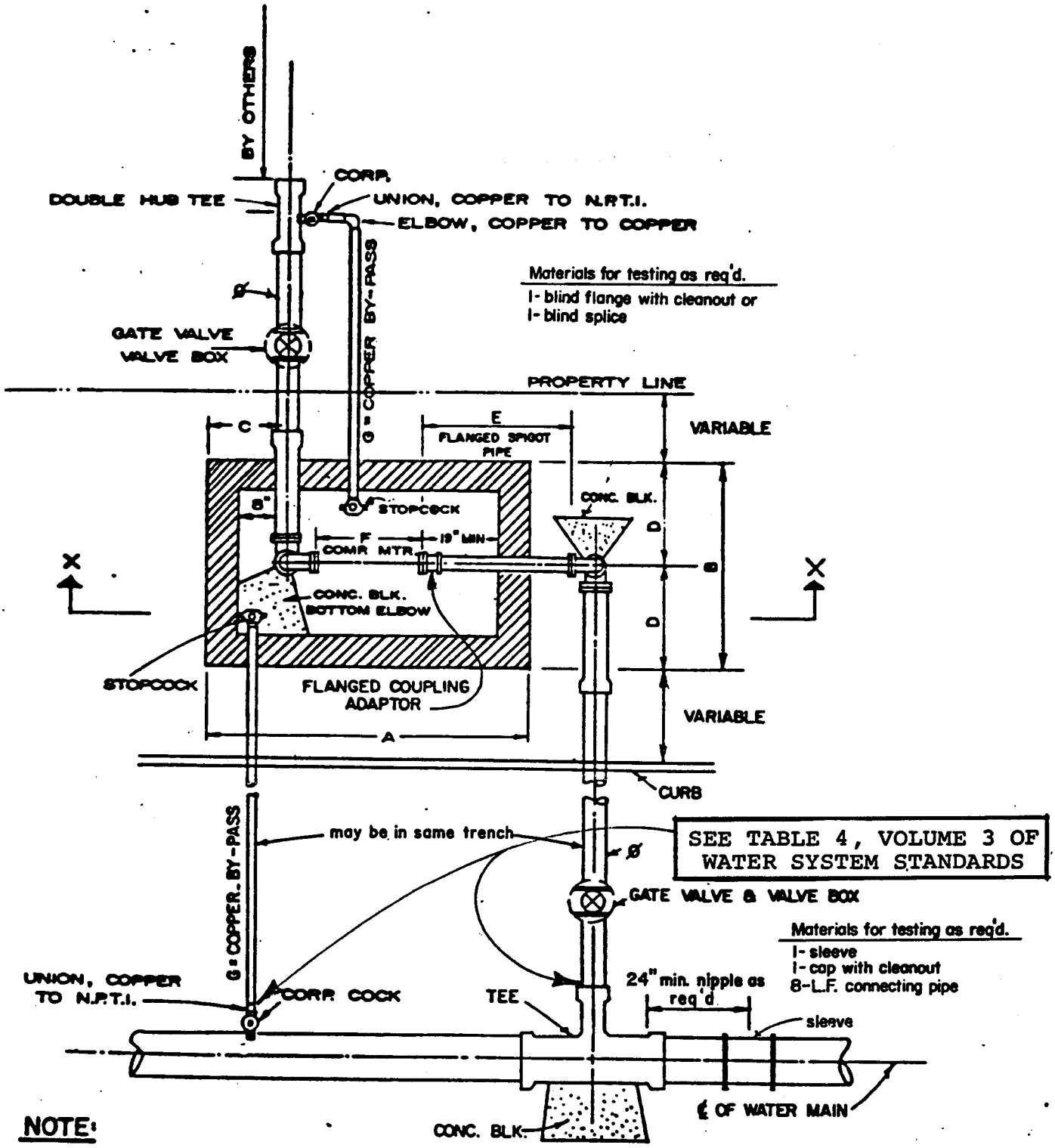
PLAN



ELEVATION

KAUAI OAHU HAWAII	OFFSET MANHOLE AIR RELIEF VALVE SCALE : NTS	STANDARD DETAILS	24

1991
1985
REVISION

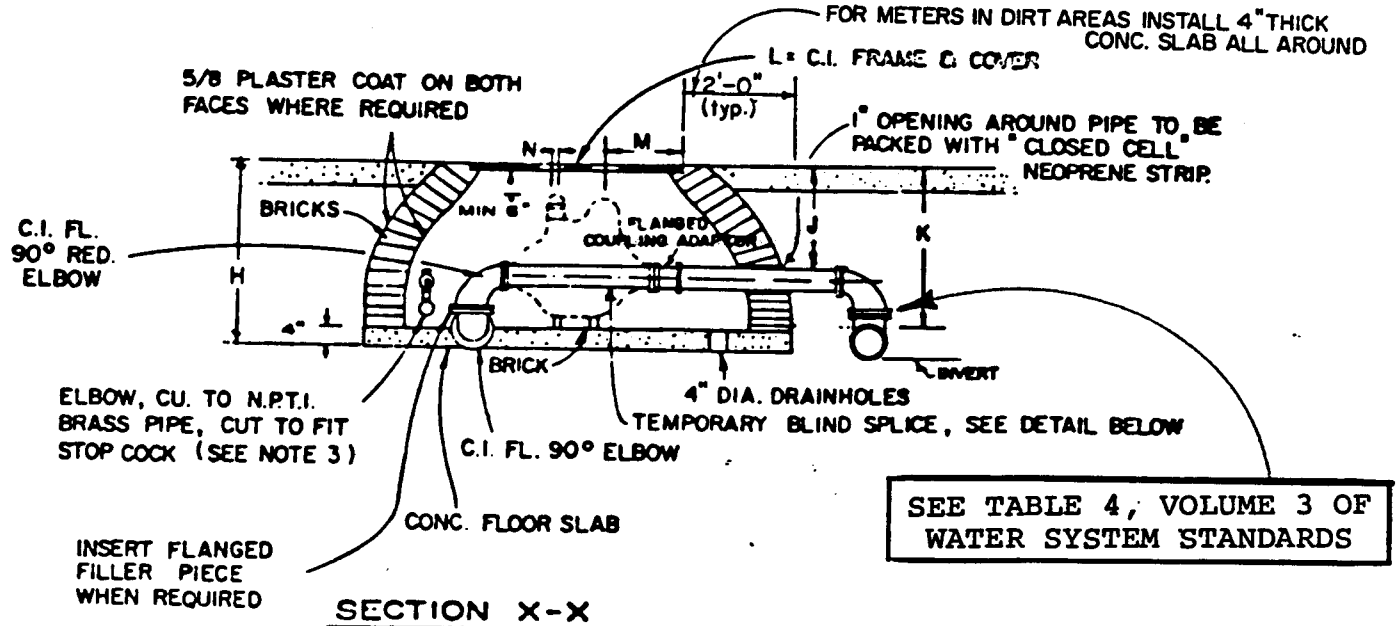


NOTE:

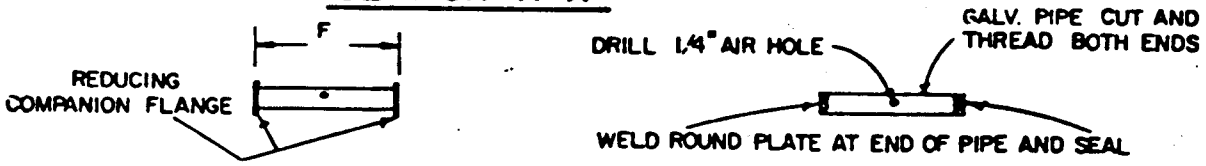
1. See Table "A", Plate 59 for dimensions based on meter size.
2. Tapping sleeve/tapping valve assembly may be used.
3. All piping shall be Ductile Iron pipe unless otherwise noted.
4. Minimum distance of tap for by-pass to tee shall be 36 inches center to center.

1991
1985
REVISION

OAHU	SINGLE COMPOUND METER INSTALLATION-PLAN SCALE : NTS	STANDARD DETAILS	57



SECTION X-X



DETAIL OF TEMPORARY BLIND SPLICE

TABLE A

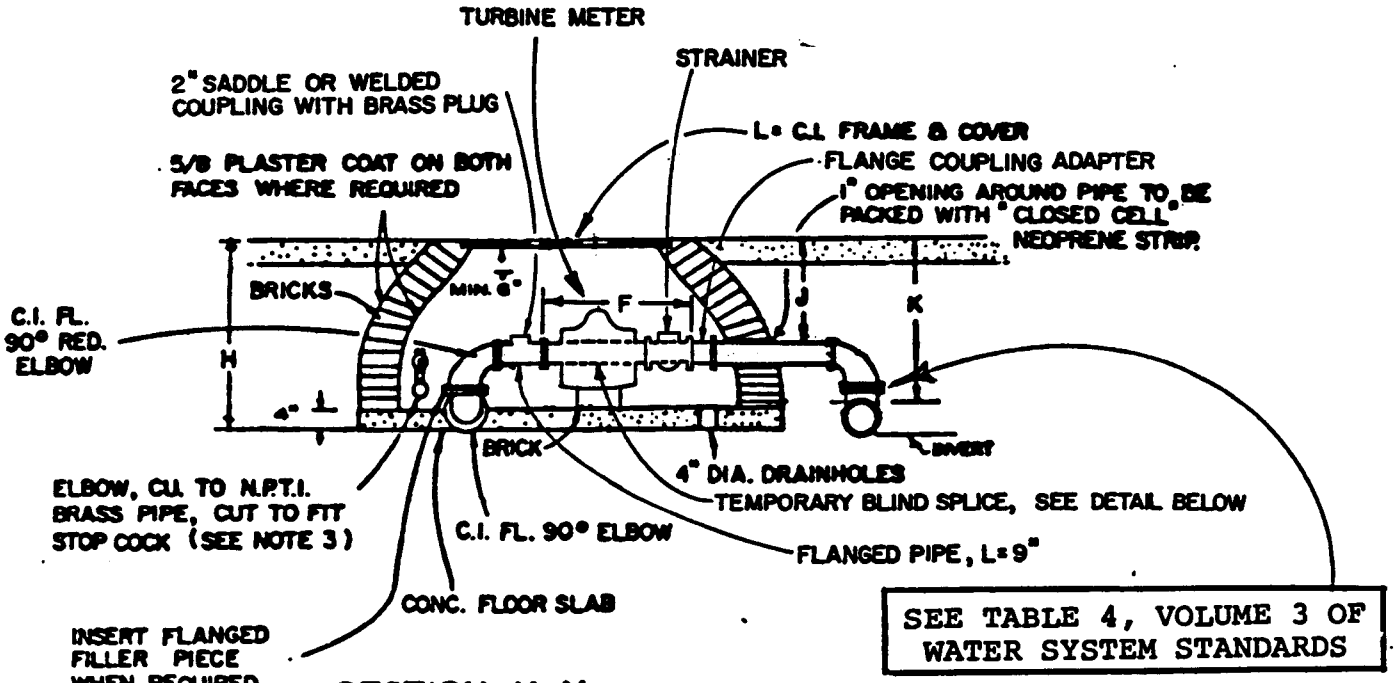
	COMPOUND METERS			
	3"	4"	6"	8"
A	7'-2"	7'-5"	7'-11"	8'-7"
B	4'-0"	4'-6"	4'-6"	4'-6"
C	1'-8 1/2"	1'-9 1/2"	1'-10 3/4"	1'-11"
D	2'-0"	2'-3"	2'-3"	2'-3"
E	3"-6"	3'-6"	3'-0"	3'-0"
F	2'-0"	2'-5"	3'-5/8"	3'-6"
G	2"	2 1/2"	2 1/2"	2 1/2"
H	2'-9 1/4"	3'-1"	3'-6"	3'-7"
J	1'-6 1/4"	1'-8 1/2"	1'-11 1/2"	1'-3"
K	2'-6 3/4"	2'-11 1/2"	3'-4 1/2"	2'-10 1/2"
L	24"x 42"	24"x42"	36"x52"	36"x52"
M	15 1/4"	15 1/4"	15"	15"
N	1"	7/8"	1/2"	1/2"
Ø	4"	4" or 6"	6" or 8"	8" or 12"

NOTES

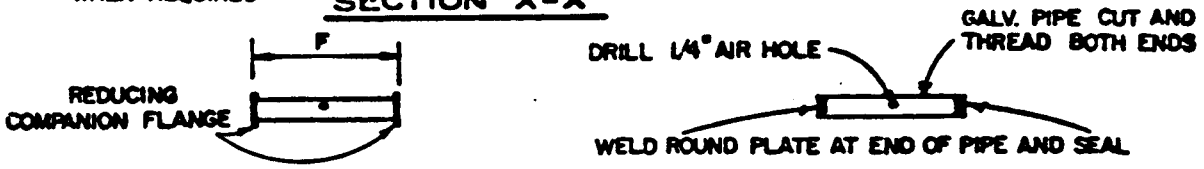
1. SEE PLATES 49,50,51 & 52 FOR METER BOX FRAME AND COVER DETAILS.
2. CONTRACTOR TO INSTALL COMPOUND METER.
3. LOCATE BY-PASS STOP COCKS IN METER BOX WITH ENOUGH SPACE BETWEEN METER AND WALL FOR TEMPORARY BY-PASS STANDPIPE TO BE HOOKED UP.
4. ELIMINATE 4" DRAINHOLES FOR WATERPROOFED MANHOLES.

1991
1985
REVISION

OAHU	SINGLE COMPOUND METER INSTALLATION—SECTION SCALE: NTS	STANDARD DETAILS	58



SECTION X-X



DETAIL OF TEMPORARY BLIND SPLICE

TABLE A

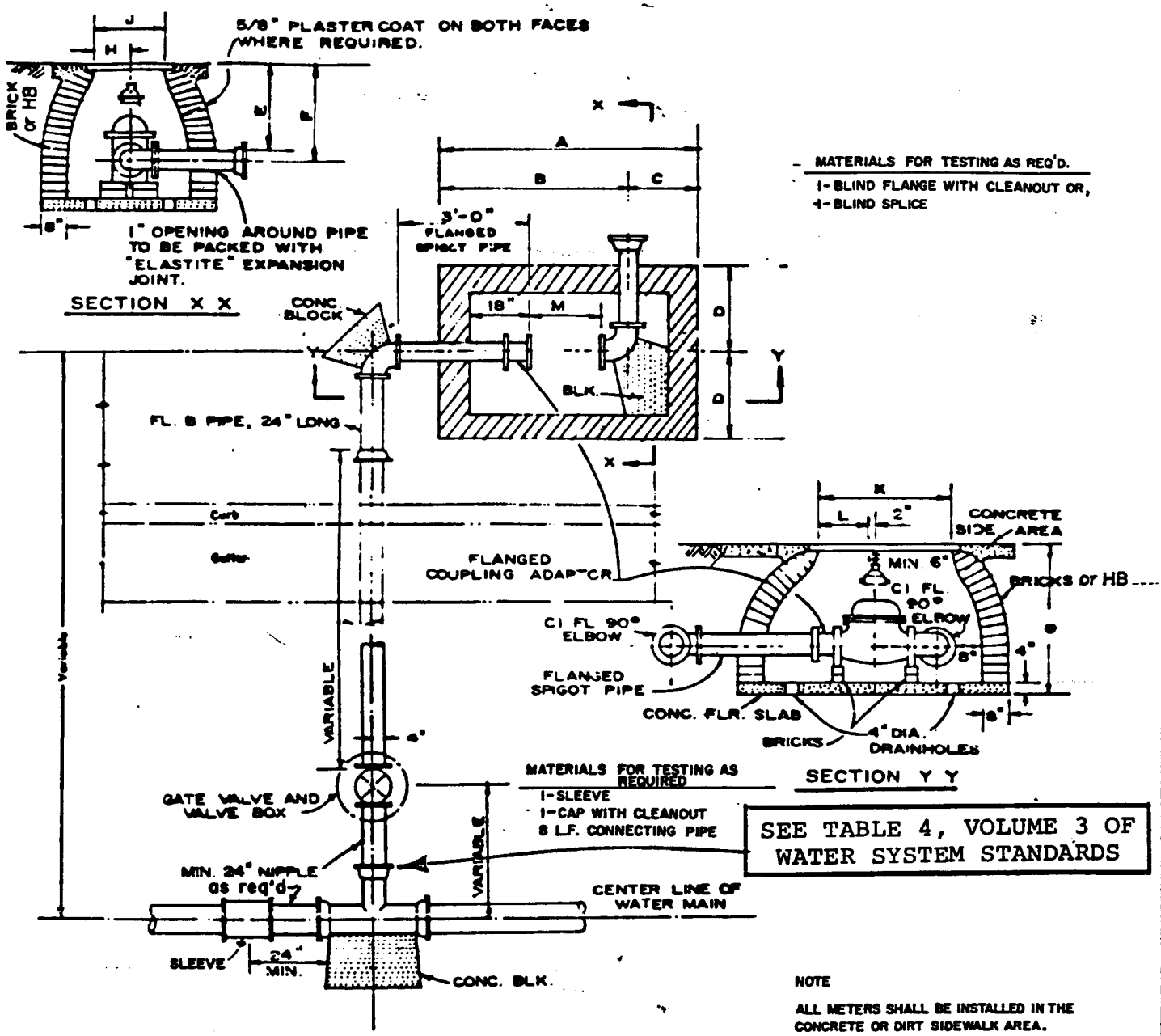
	TURBINE METERS			
	3"	4"	6"	8"
A	7'-2"	7'-5"	7'-11"	8'-7"
B	4'-0"	4'-6"	4'-6"	4'-6"
C	1'-8 1/2"	1'-9 1/2"	1'-10 3/4"	1'-11"
D	2'-0"	2'-3"	2'-3"	2'-3"
E	3'-6"	3'-6"	3'-0"	3'-0"
F	1'-6"	1'-11"	2'-3"	2'-6"
G	2"	2 1/2"	2 1/2"	2 1/2"
H	2'-9 1/4"	3'-1"	3'-6"	3'-7"
J	1'-6 1/4"	1'-8 1/2"	1'-11 1/2"	1'-3"
K	2'-6 3/4"	2'-11 1/2"	3'-4 1/2"	2'-10 1/2"
L	24"x42"	24"x42"	36"x52"	36"x52"
ø	4"	4" or 6"	6" or 8"	8" or 12"

NOTES

1. SEE PLATES 49,50,51 & 52 FOR METER BOX FRAME AND COVER DETAILS.
2. CONTRACTOR TO INSTALL TURBINE METER.
3. LOCATE BY-PASS STOP COCKS IN METER BOX WITH ENOUGH SPACE BETWEEN METER AND WALL FOR TEMPORARY BY-PASS STANDPIPE TO BE HOOKED UP.
4. ELIMINATE 4" DRAINHOLES FOR WATERPROOFED MANHOLES.
5. CENTER DIAL UNDER READING COVER.
6. 2" TURBINE METER SHALL BE INSTALLED AS SHOWN IN PLATE 92.

1991
1985
REVISION

OAHU	TURBINE METER INSTALLATION—SECTION SCALE: NTS	STANDARD DETAILS	59

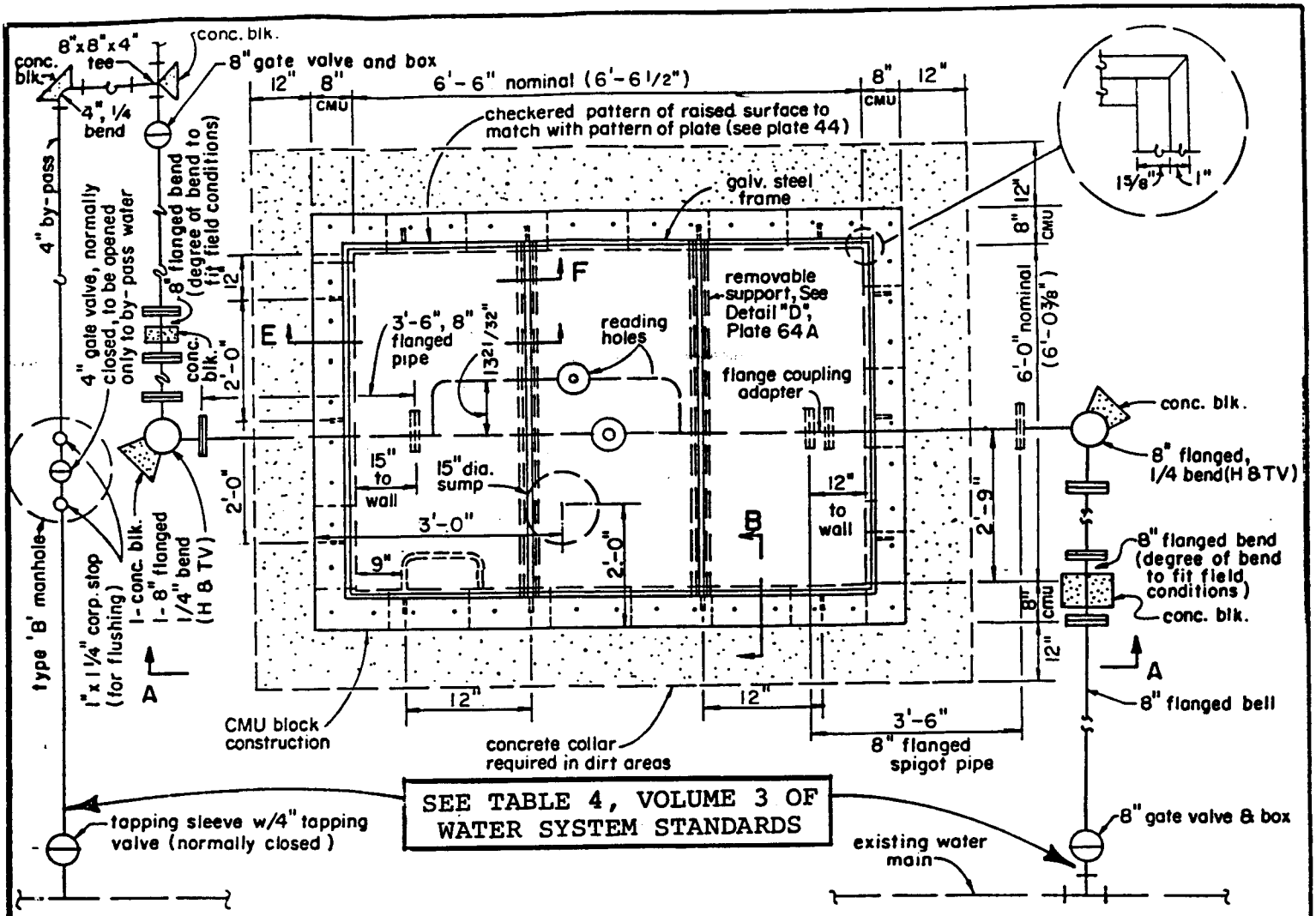


METER SIZE	A	B	C	D	E	F	G	H	C.I. FRAME & COVER		L	M
									J	K		
4" x 5/8	5'-9 1/2	4'-1"	81/2"	2'-0"	min. 2'-0"	min. 2'-2 1/2"	min. 3'-4 1/2"	1'-0"	24"	42"	15 3/4	1'-4 1/2"
6" x 5/8	6'-6"	4'-8 1/2	91/2"	2'-3"	min. 2'-3"	min. 2'-6 1/2"	min. 3'-9 1/2"	1'-0"	24"	42"	15 3/4	1'-10 1/2"
8" x 1"	7'-1/4"	5'-1 1/2	10 3/4"	2'-8"	min. 2'-9"	min. 3'-1 1/2"	min. 4'-6".	1'-6"	36"	52"	23"	2'-2 1/2"

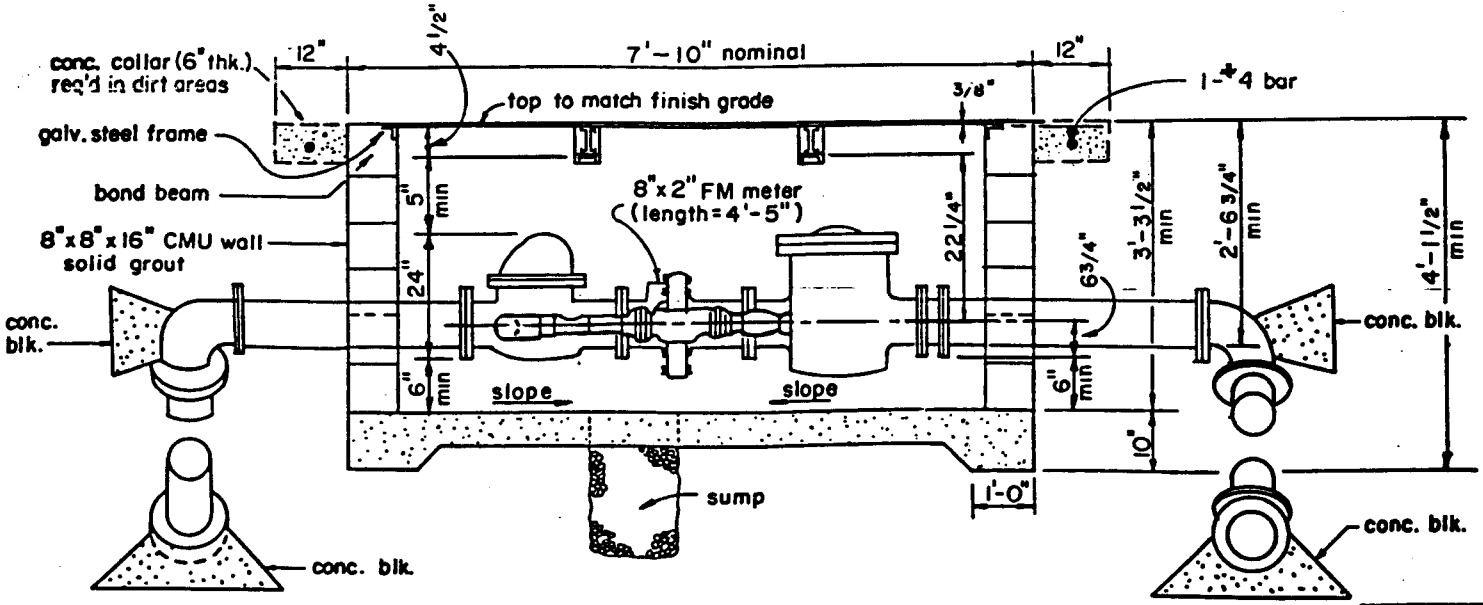
NOTE:
MAXIMUM DEPTH FOR "E", "F", AND "G" SHALL BE 1'-0" MORE THAN SHOWN IN TABLE.

1991
1985
REVISION

OAHU	SINGLE DETECTOR CHECK METER INSTALLATION SCALE: N.T.S.	STANDARD DETAILS	62



Plan View of Galv. Steel Frame and Removable Support

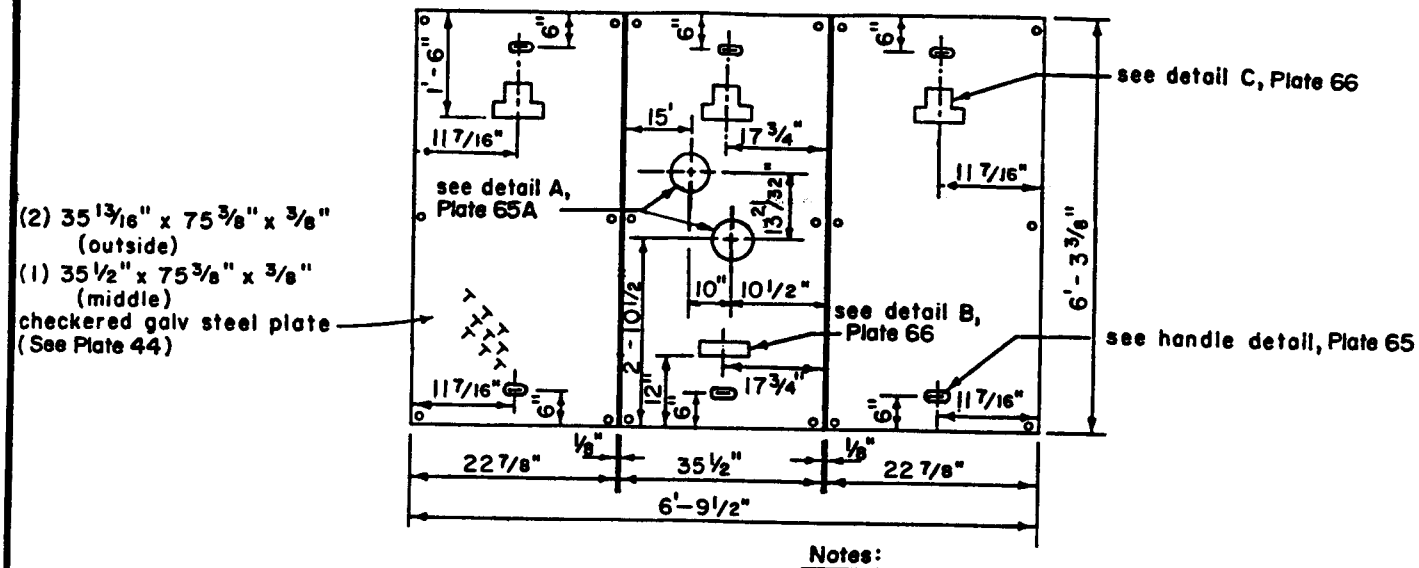


Section "A-A"

Scale : NTS

1991
1986
REVISION

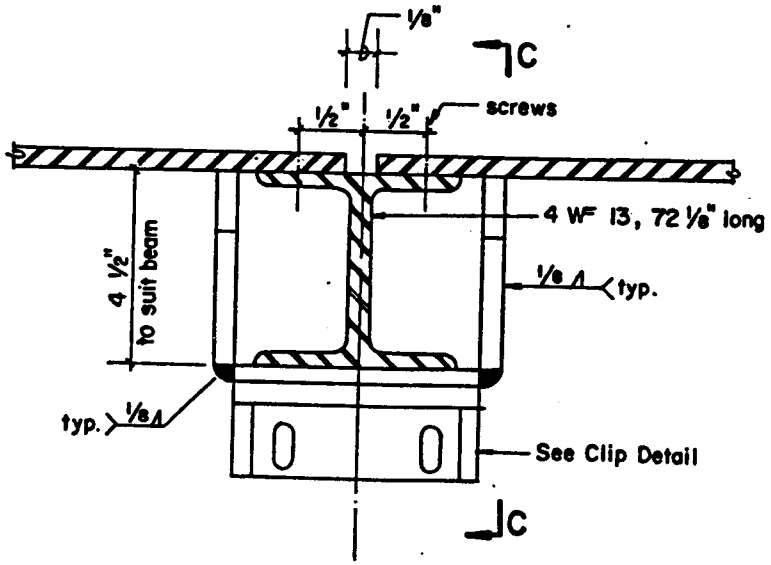
OAHU	**FM METER & BOX** **LAYOUT** FIRE AND DOMESTIC USES	STANDARD DETAILS	64



Notes:

1. Contractor to verify all dimensions prior to fabrication.
2. Location of reading lid shall be verified by contractor.

Plan – FM Meter Cover

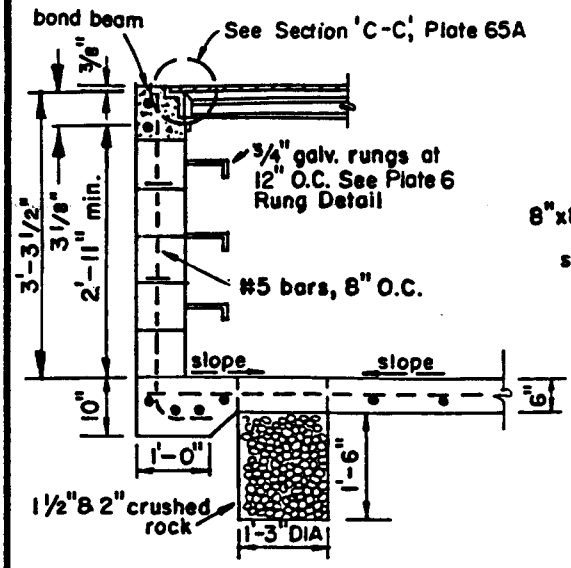


Detail 'D'
Removable Support

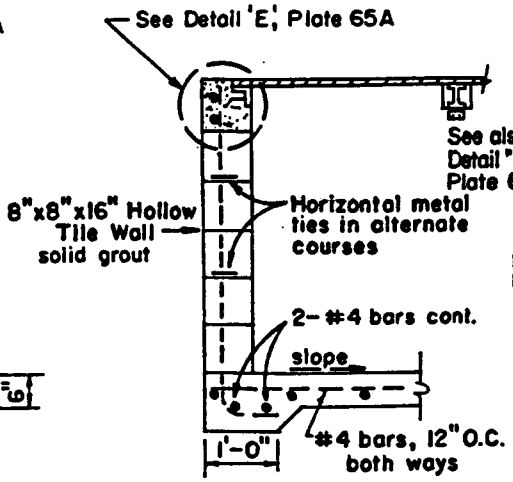
1991
1986
Revision

Scale: NTS

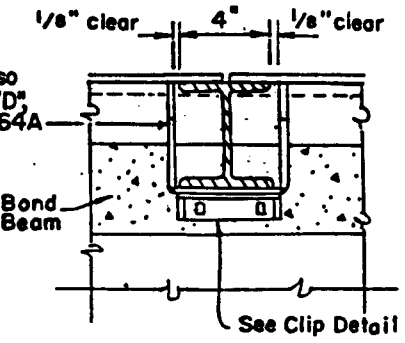
Oahu	FM METER & BOX COVER PLATE & SUPPORT DETAILS	STANDARD DETAILS	64A



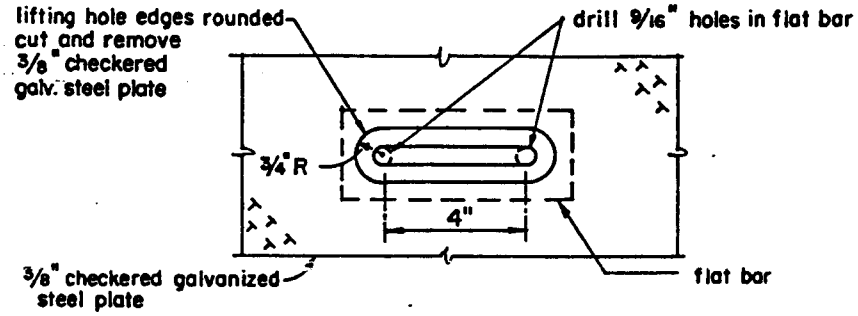
Section "B-B"



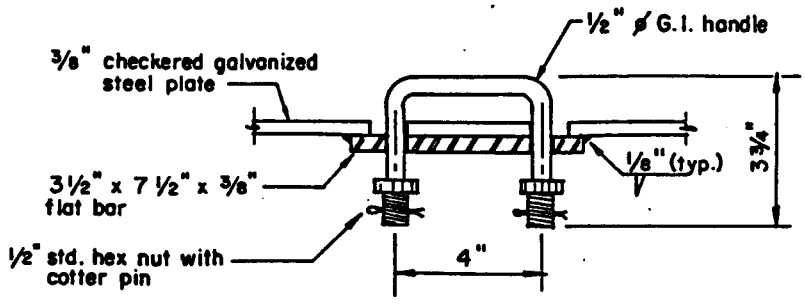
Section "E-E"



Section "F-F"



Plan



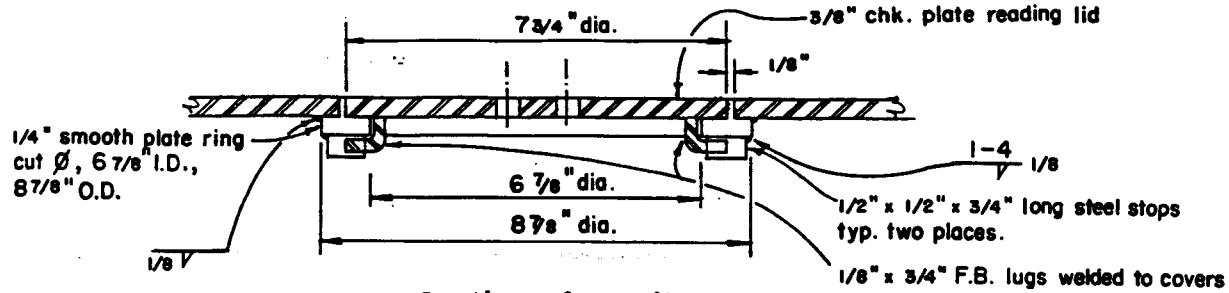
Section

Handle Detail

1991
1986
REVISION

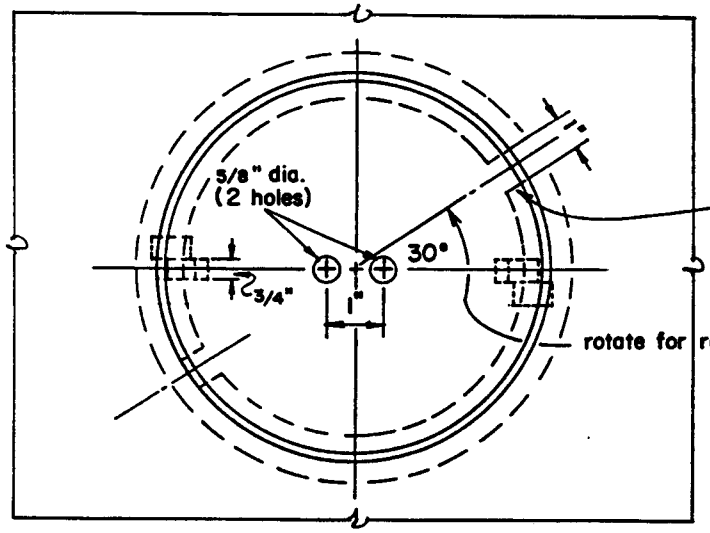
Scale : NTS

OAHU	FM METER & BOX BOX DETAILS	STANDARD DETAILS	65



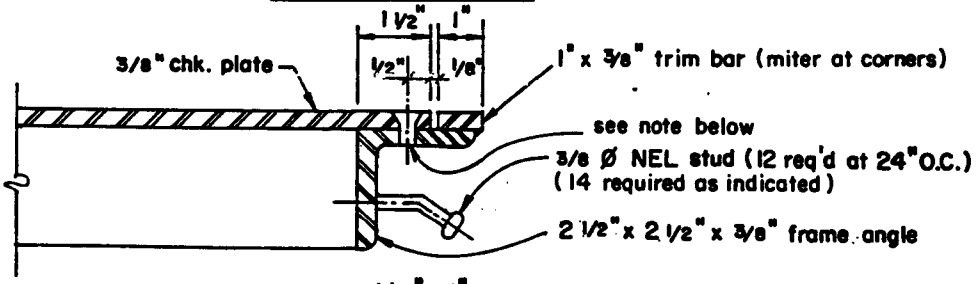
Section of Detail A

Typical Reading Lid

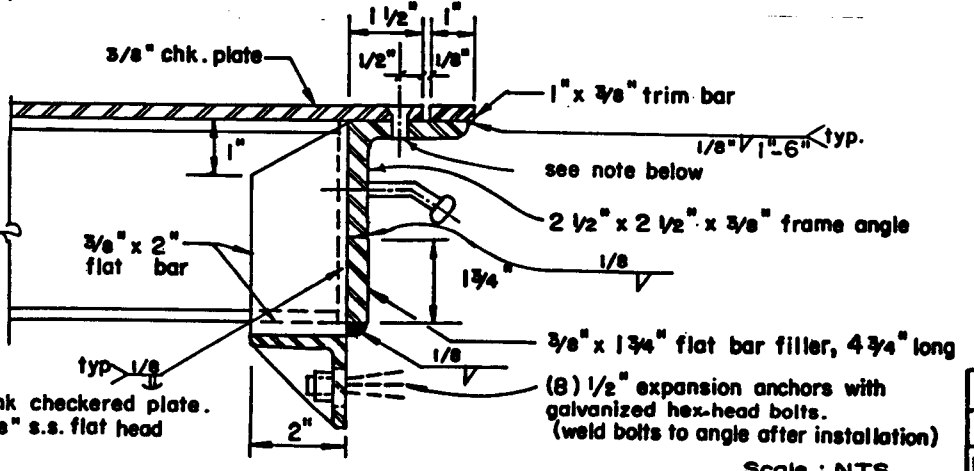


Detail A - Plan

Detail E



Section 'C-C'



Note

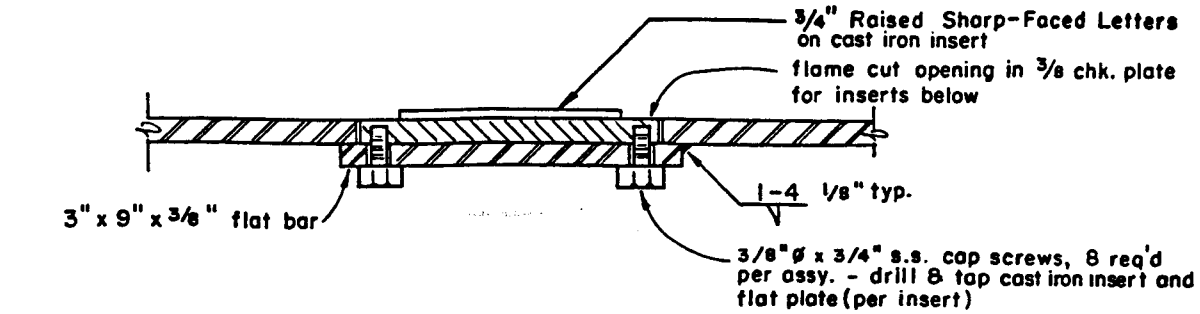
(18) drill and countersink checkered plate. drill and tap angle for 3/8" s.s. flat head machine screws.

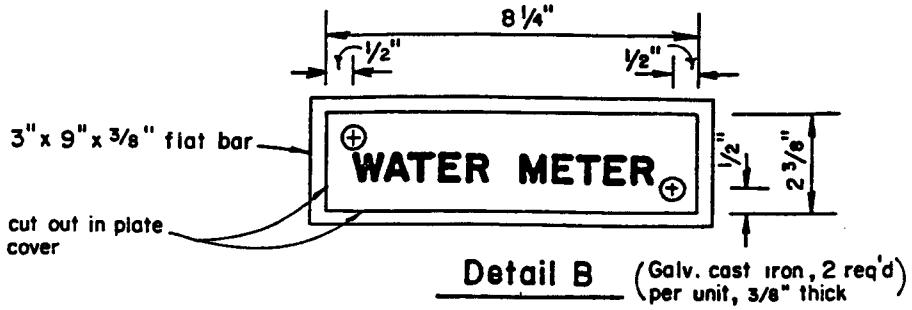
1986

REVISION

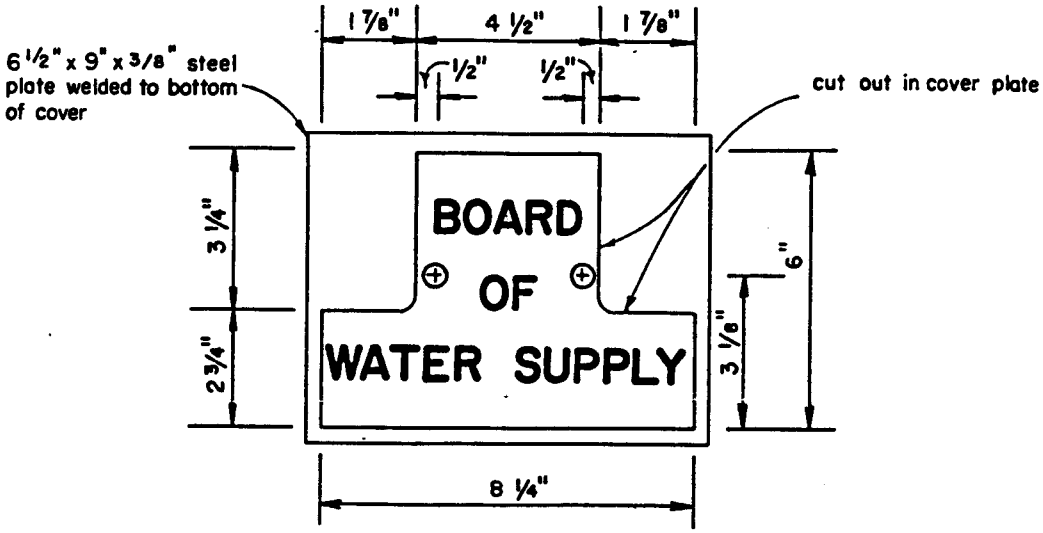
Scale : NTS

OAHU	**FM METER & BOX** READING LID & FRAME DETAILS	STANDARD DETAILS	65A

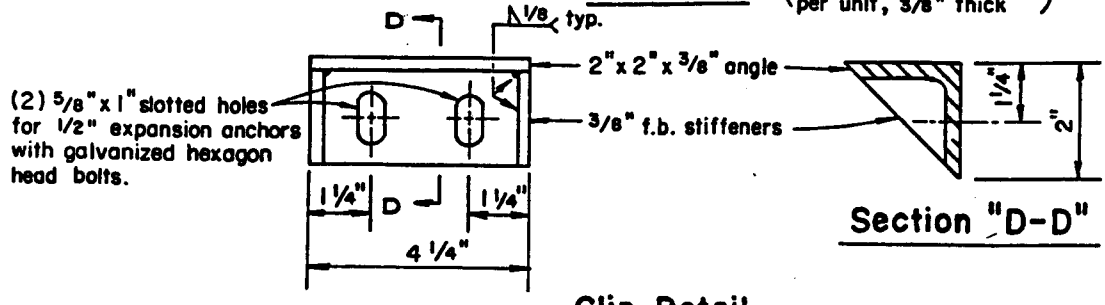




Detail B (Galv. cast iron, 2 req'd per unit, 3/8" thick)



Detail C (Galv. cast. iron, 1 req'd per unit, 3/8" thick)



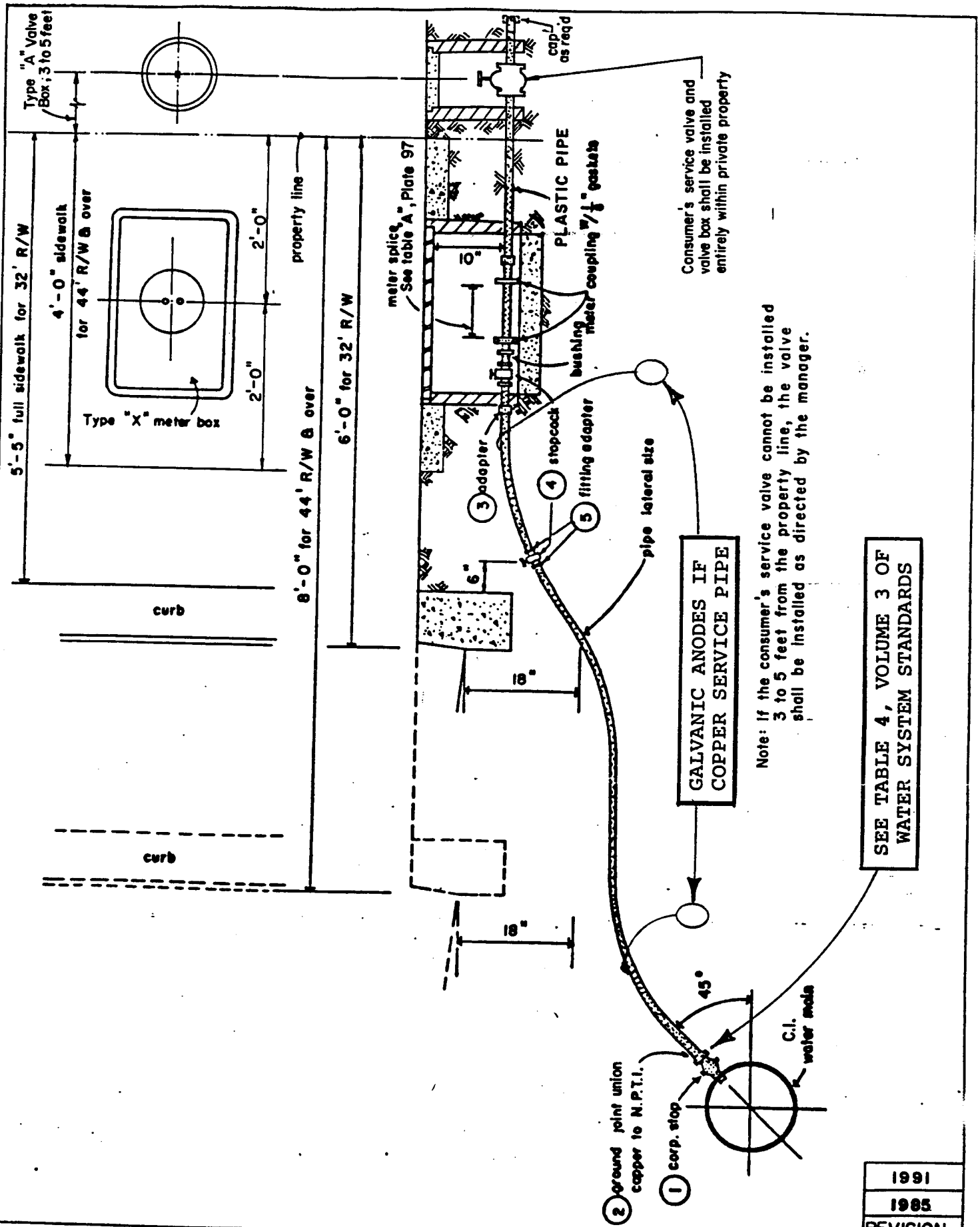
Clip Detail
(2 req'd. per unit)

Section "D-D"

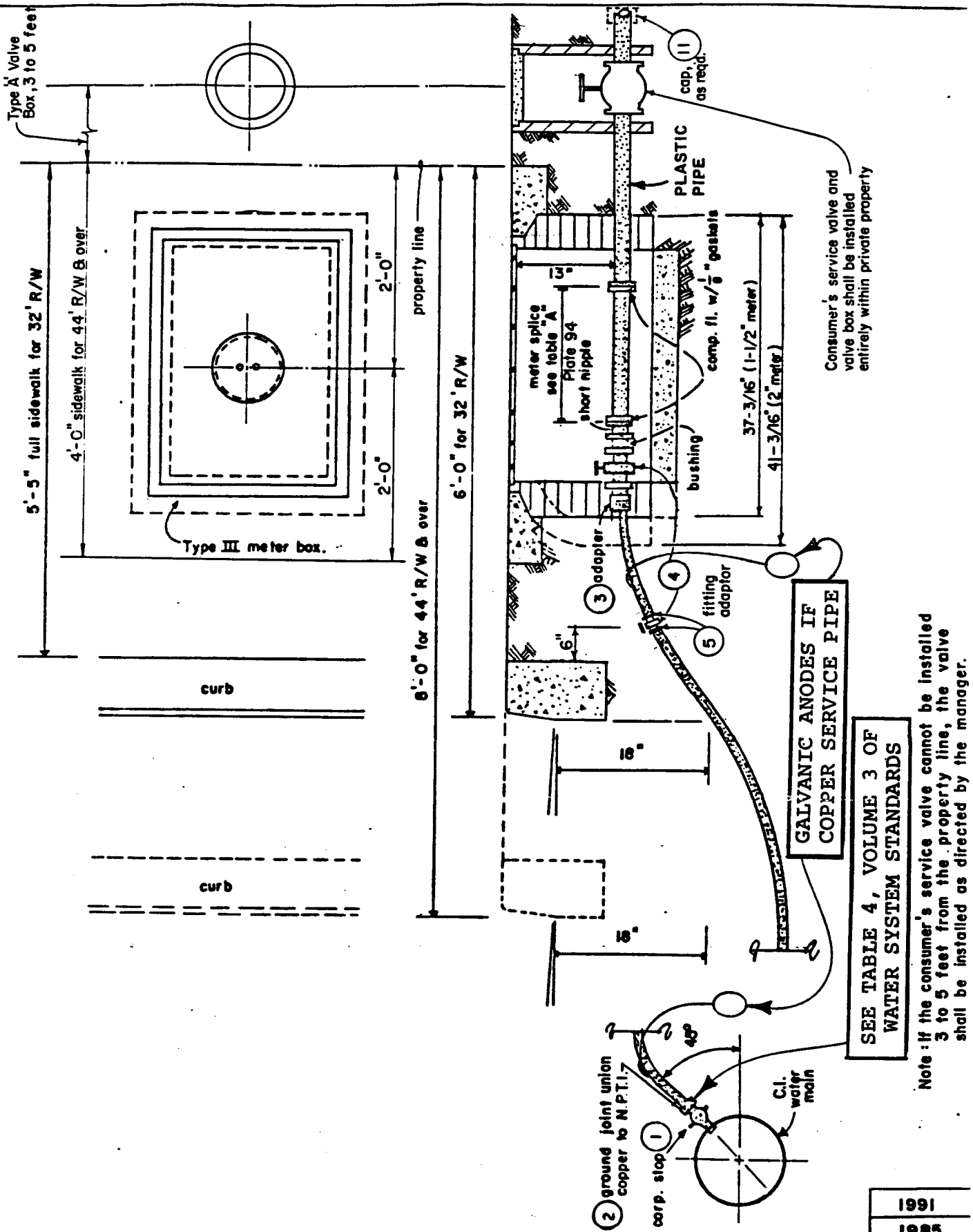
1991
1986
REVISION

Scale : NTS

OAHU	**FM METER & BOX** IDENTIFICATION INSERTS AND CLIP DETAILS	STANDARD DETAILS	66



OAHU	**COPPER SERVICE LATERAL FOR CONNECTION TYPE "X" METER BOX 5/8", 3/4", & 1" METERS** SCALE: NTS	STANDARD DETAILS	1991 1985 REVISION **91**



Note: If the consumer's service valve cannot be installed 3 to 5 feet from the property line, the valve shall be installed as directed by the manager.

OAHU	**COPPER SERVICE LATERAL** FOR CONNECTION TYPE III MTR. BOX, 1 1/2" & 2" METERS SCALE: NTS	STANDARD DETAILS	92

1991
1985
REVISION

OAHU

COPPER SERVICE LATERAL FOR CONNECTION MULTIPLE SERVICE

SCALE: NTS

STANDARD DETAILS

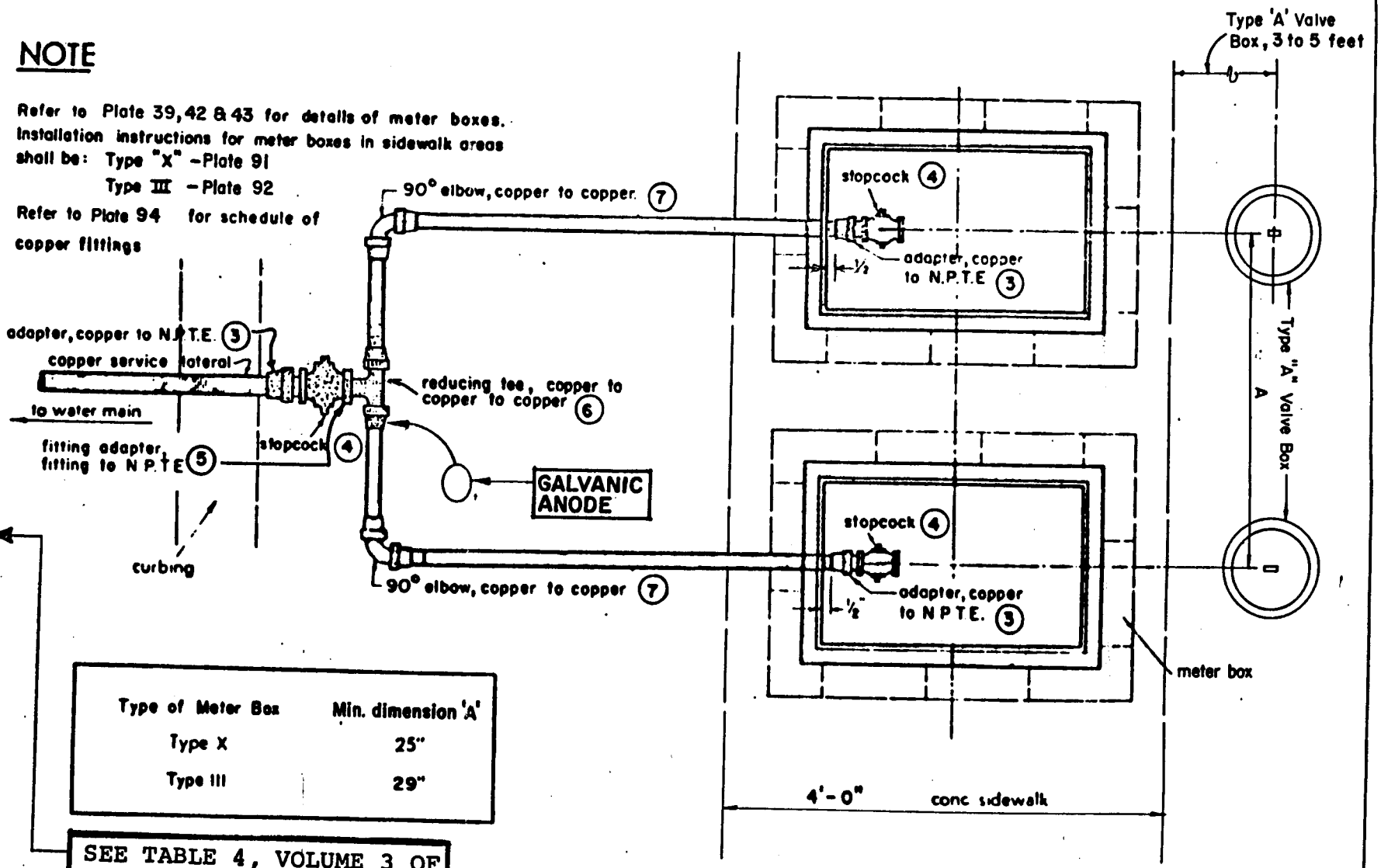
93

REVISION 1985 1991

NOTE

Refer to Plate 39, 42 & 43 for details of meter boxes.
Installation instructions for meter boxes in sidewalk areas shall be: Type "X" – Plate 91
Type III – Plate 92

Refer to Plate 94 for schedule of copper fittings



Type of Meter Box	Min. dimension 'A'
Type X	25"
Type III	29"

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS AND INSTALL ANODE AT TAP

Note: If the consumer's service valve cannot be installed 3 to 5 feet from the property line, the valve shall be installed as directed by the manager.

ITEM NO.	DESCRIPTION	SINGLE SERVICE CONN.	CONNECTION FOR TWO SERVICES
1	Corporation Stop, Bronze	1	1
2	Ground Joint Union, Copper To N.P.T.I.	1	1
3	Adapter, Copper To N.P.T.E.	1	3
4	Stopcock, Bronze	1	3
5	Fitting Adapter, Fitting To N.P.T.E.	2	1
6	Reducing Tee, Copper To Copper To Copper	-	1
7	90° Elbow, Copper to Copper	-	2

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS

SCHEDULE OF COPPER FITTINGS

1991
1985
REVISION

OAHU	SERVICE LATERAL AND CONNECTION FITTING SCHEDULE SCALE:	STANDARD DETAILS	94

OAHU

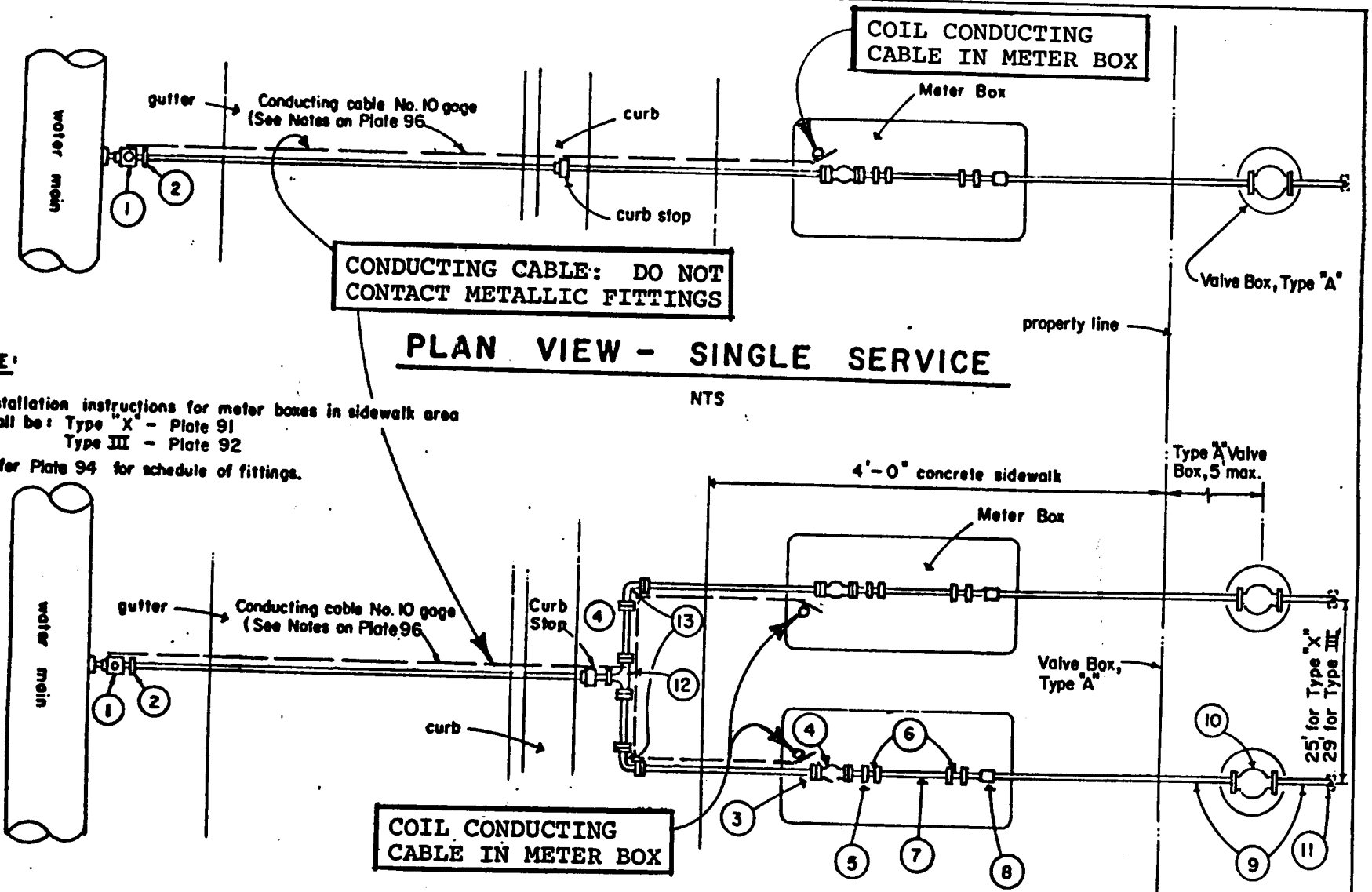
PLASTIC SERVICE LATERAL FOR CONNECTION

SCALE: NTS

STANDARD DETAILS

95

REVISION	
1985	
1991	



PLAN VIEW - SINGLE SERVICE

NTS

NOTE:

1. Installation instructions for meter boxes in sidewalk area shall be: Type "X" - Plate 91
   Type III - Plate 92
2. Refer Plate 94 for schedule of fittings.

PLAN VIEW - MULTIPLE SERVICE

NTS

CAHU

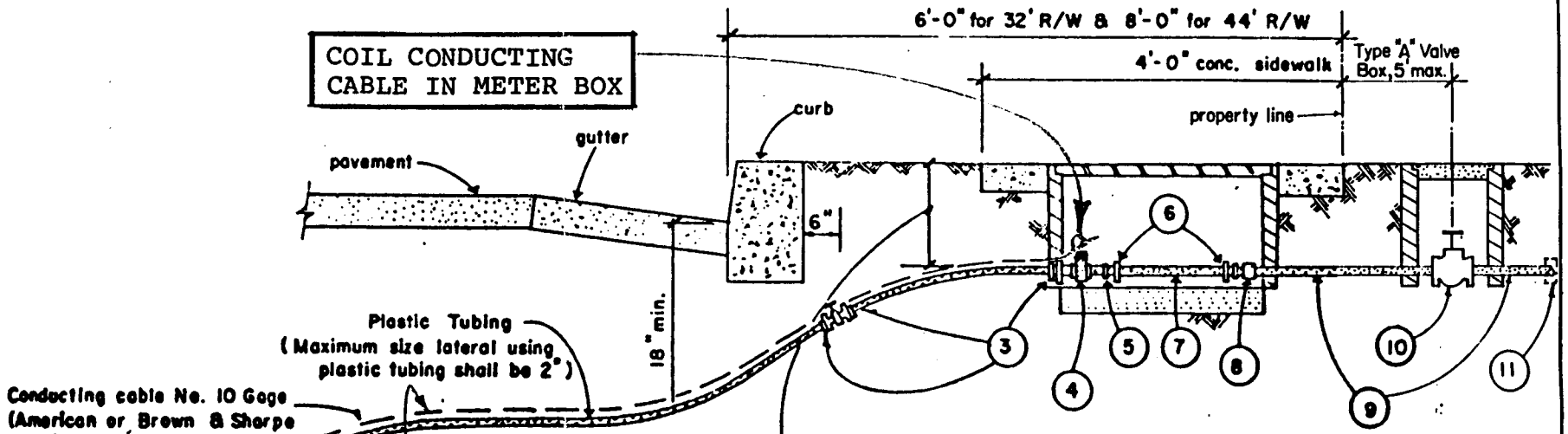
PLASTIC SERVICE LATERAL FOR CONNECTION ELEVATION

SCALE: NTS

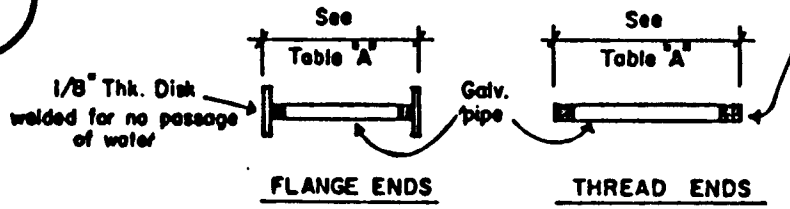
STANDARD DETAILS

96

REVISION	
1985	
1991	

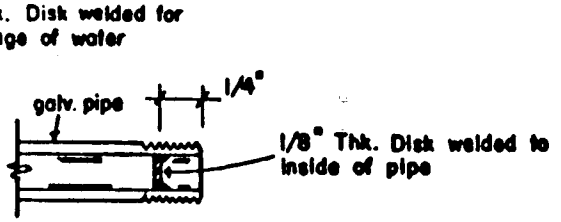


PLASTIC SERVICE LATERAL



METER SPLICE DET.

NTS

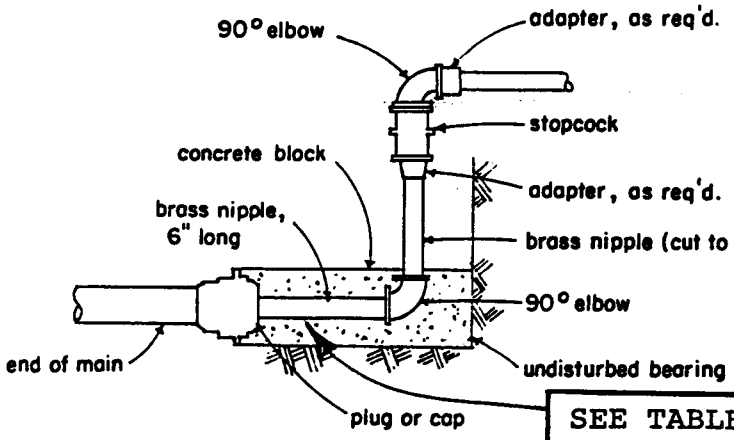


DISK DET.

NTS

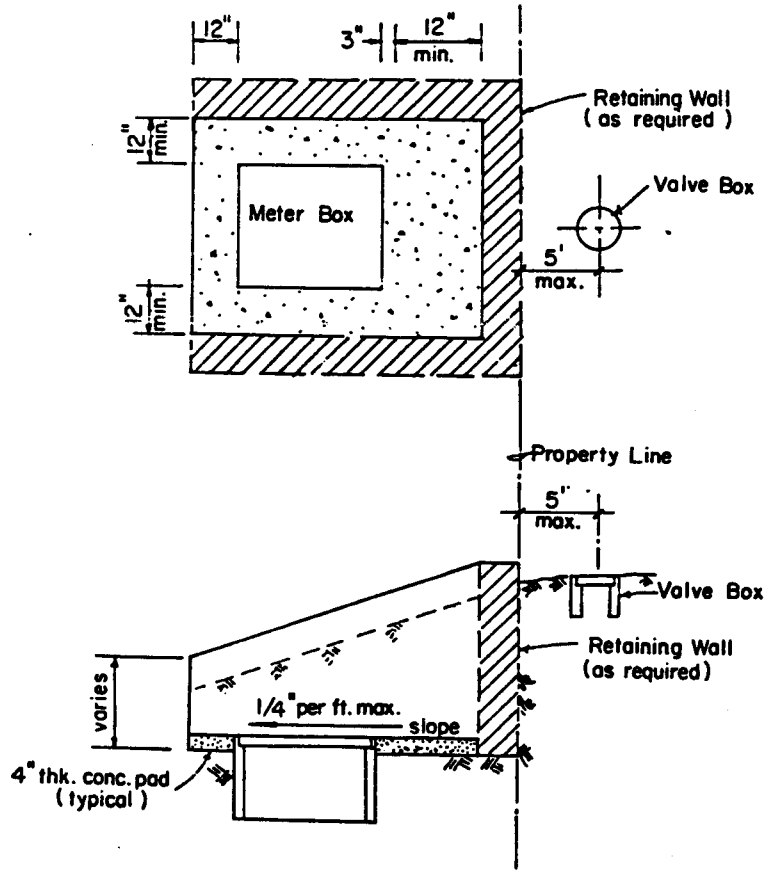
NOTES:

1. Refer to Plate 97 for schedule of fittings.
2. Meter Couplings: Screw end type for 5/8" through 1" meter connections. Flange-end type for 1 1/2" and 2" meter connections. Companion flange to conform to AWWA C 700-71 for cold water meters - displacement.
3. Plastic tubing shall be of ultra-high molecular weight polyethylene, meeting the requirements of ASTM Material Classication PE-3406.
4. Stainless steel stiffners shall be required for plastic tubings with compression type fittings.
5. Splices to be installed with 1/8" gaskets at each end.
6. Conducting cable shall be solid, one piece copper wire, No. 10 gage or larger, tied to plastic tubing with copper wire at 4 o.c., from Corp Stop to the stopcock.
7. For multiple service laterals, run conducting cable from Corp Stop to tee where the lateral branches (curbstop) and then to stopcocks.
8. CONDUCTING CABLE SHALL NOT CONTACT ANY METALLIC FITTINGS



SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS

SERVICE LATERAL CONNECTION AT END OF LINE



Notes:

1. Avoid placement of meters in swale areas.
2. Meter/conc. slab detail may be rotated 90° to fit in tight areas.
3. Retaining wall required if existing or finish ground has slope greater than 1/4" per foot.

WATER METER BOX DETAIL FOR NON-SIDEWALK AREAS

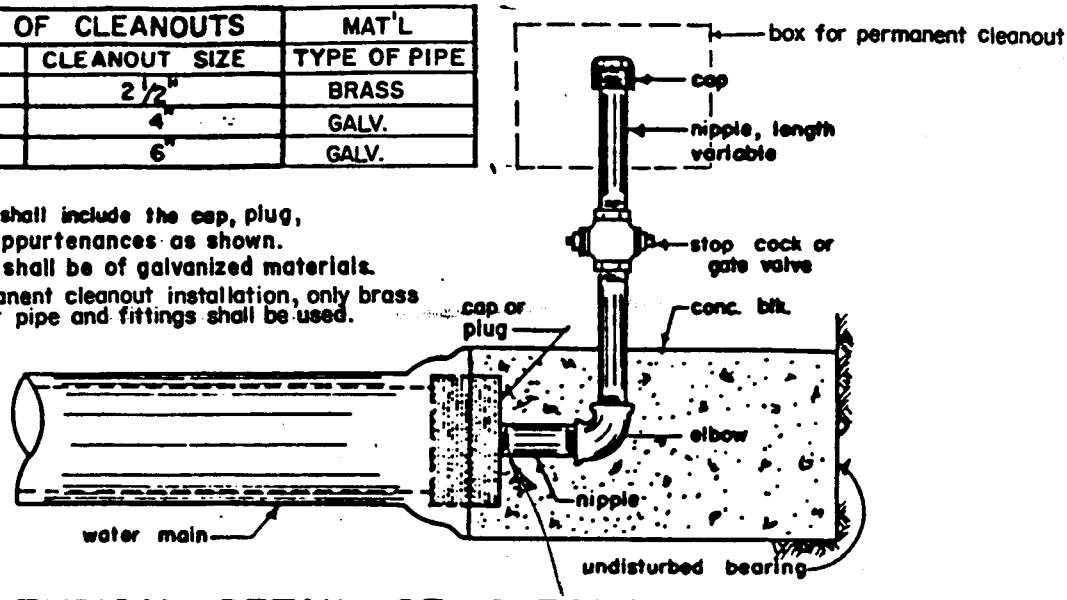
1991
1985
REVISION

OAHU	END OF LINE CONNECTION, WATER METER BOX FOR NON-SIDEWALK AREAS Scale: NTS	STANDARD DETAILS	98

SCHEDULE OF CLEANOUTS		MAT'L
PIPE SIZE	CLEANOUT SIZE	TYPE OF PIPE
8" & smaller	2 1/2"	BRASS
12" to 20"	4"	GALV.
24" & larger	6"	GALV.

NOTES:

1. Cleanout shall include the cap, plug, and all appurtenances as shown.
2. All pipes shall be of galvanized materials.
3. For permanent cleanout installation, only brass or copper pipe and fittings shall be used.



TYPICAL DETAIL OF CLEANOUT

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS

1991
1985
REVISION

OAHU	CLEANOUTS AND RISER	STANDARD DETAILS	102
	SCALE : NTS		

KAUAI
OAHU
MAUI
HAWAII

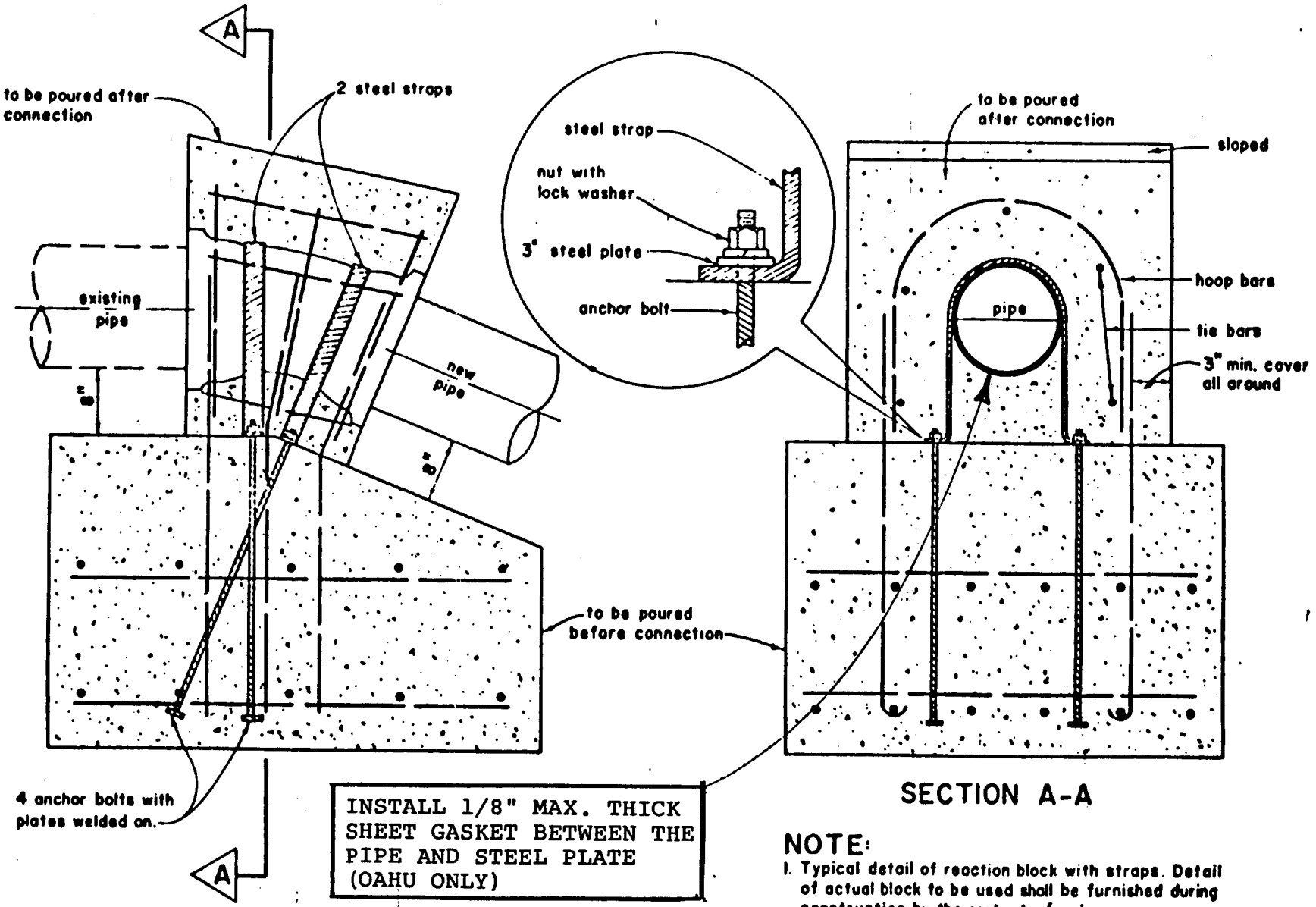
TYPICAL THRUST BLOCK WITH STRAPS FOR CONNECTIONS AT VERTICAL BEND

SCALE: NTS

STANDARD DETAILS

108

REVISION
1985
1991

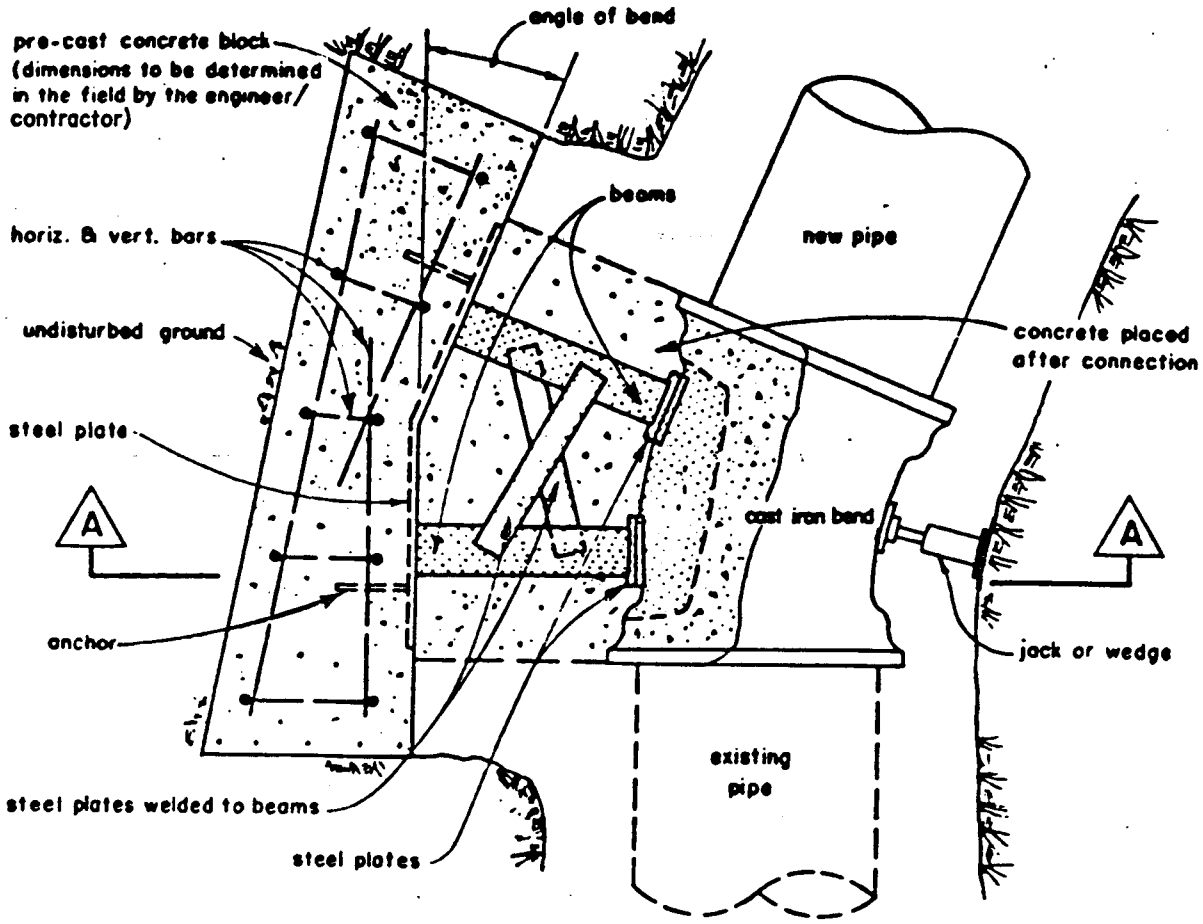


INSTALL 1/8" MAX. THICK SHEET GASKET BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)

SECTION A-A

NOTE:

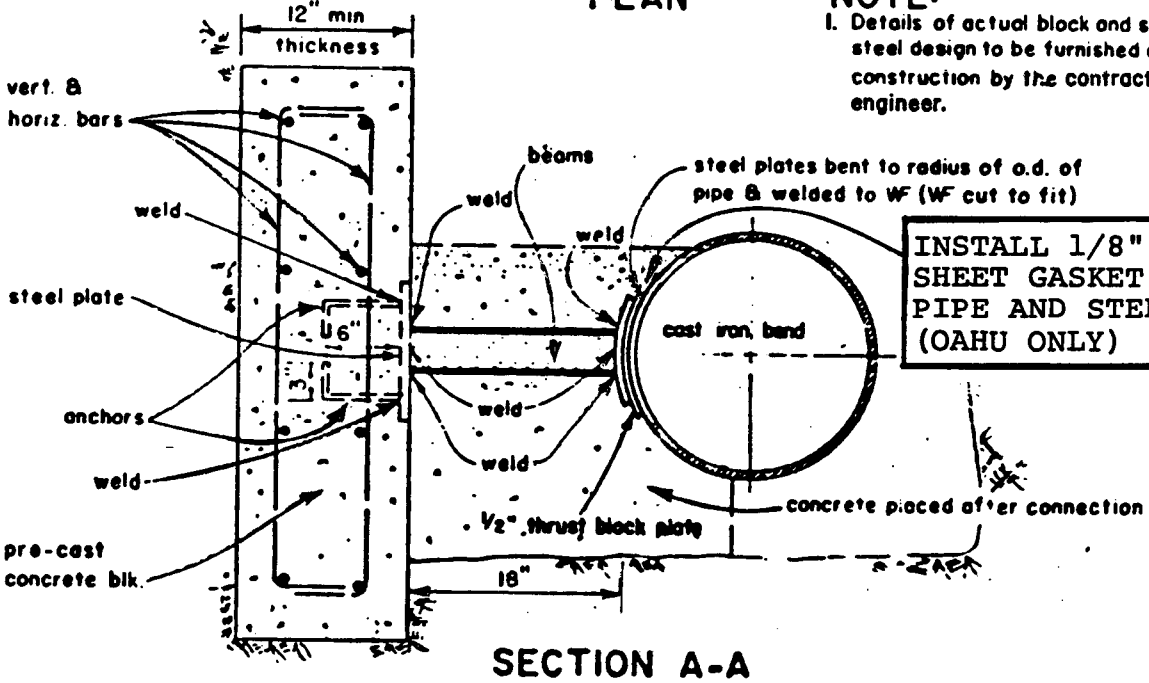
1. Typical detail of reaction block with straps. Detail of actual block to be used shall be furnished during construction by the contractor/engineer.
2. Anchor bolts shall be placed perpendicular to the bend at the strap.



PLAN

NOTE:

1. Details of actual block and structural steel design to be furnished during construction by the contractor or engineer.

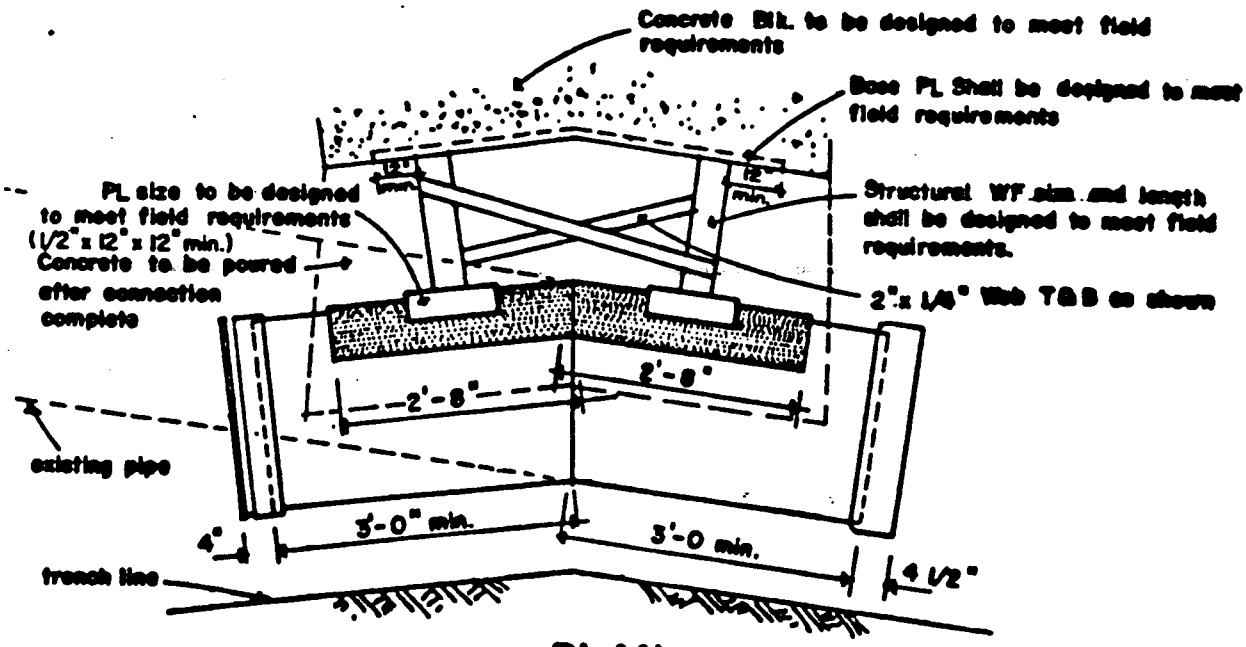


INSTALL 1/8" MAX. THICK SHEET GASKET BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)

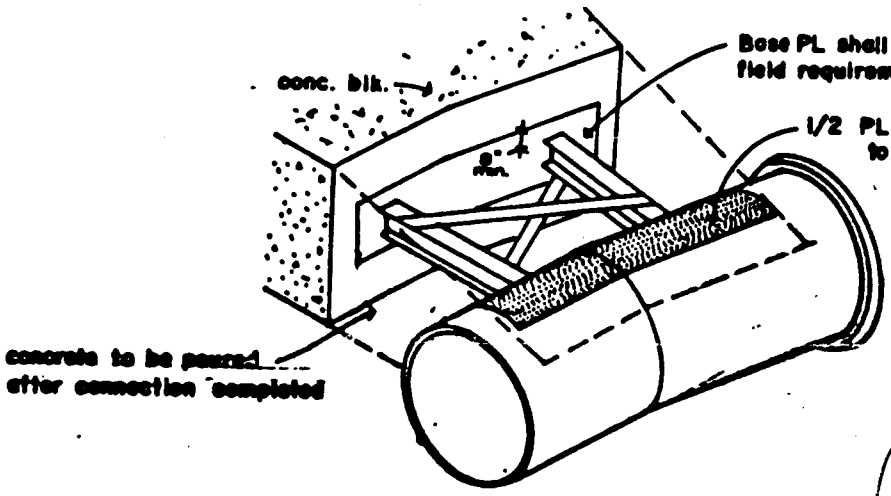
SECTION A-A

1991
1985
REVISION

KAUAI OAHU MAUI HAWAII	**TYPICAL THRUST BLOCK WITH STRUCTURAL STRUT FOR CONNECTIONS** SCALE : NTS	STANDARD DETAILS	109

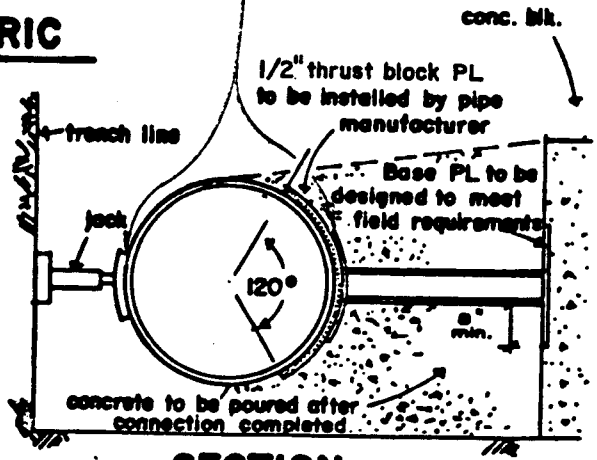


PLAN



ISOMETRIC

1/8" MAX. THICK SHEET GASKET RUBBER TO BE INSTALLED BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)



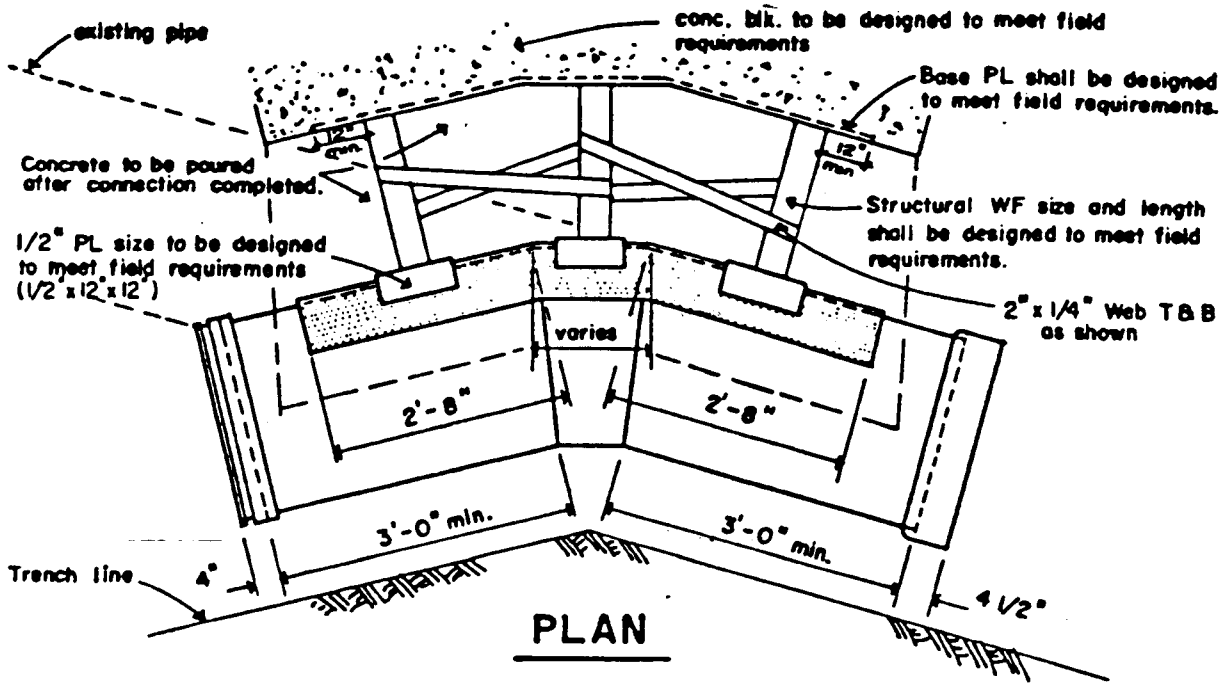
SECTION

NOTES:

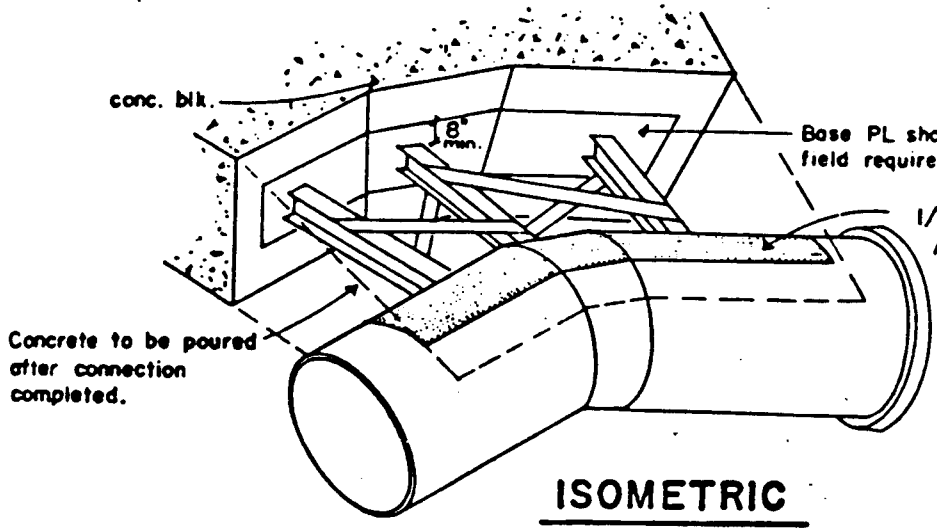
1. All welds shall conform to AWS standards.
2. PL shall be uncoated ready to receive thrust struts and appurtenances.
3. Deliver at request.
4. Number of struts to be used may vary according to the working pressure.

KAUAI OAHU MAUI	**TYPICAL THRUST BLOCK PLATE** 6°–22 1/2° CONCRETE CYL. BEND FOR CONNECTIONS ONLY 16"–42" SCALE: NTS	STANDARD DETAILS	111

1991
1985 _ _
REVISION

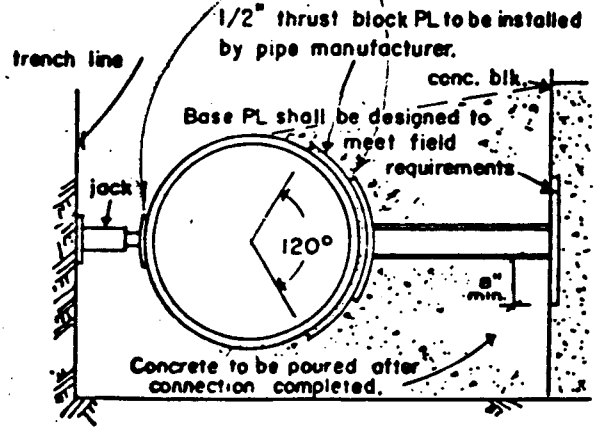


PLAN



ISOMETRIC

1/8" MAX. THICK SHEET GASKET RUBBER TO BE INSTALLED BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)



SECTION

NOTES:

1. All welds shall conform to AWS standards.
2. PL shall be uncoated ready to receive thrust struts and appurtenances.
3. Deliver at request.
4. Number of struts to be used may vary according to the working pressure.

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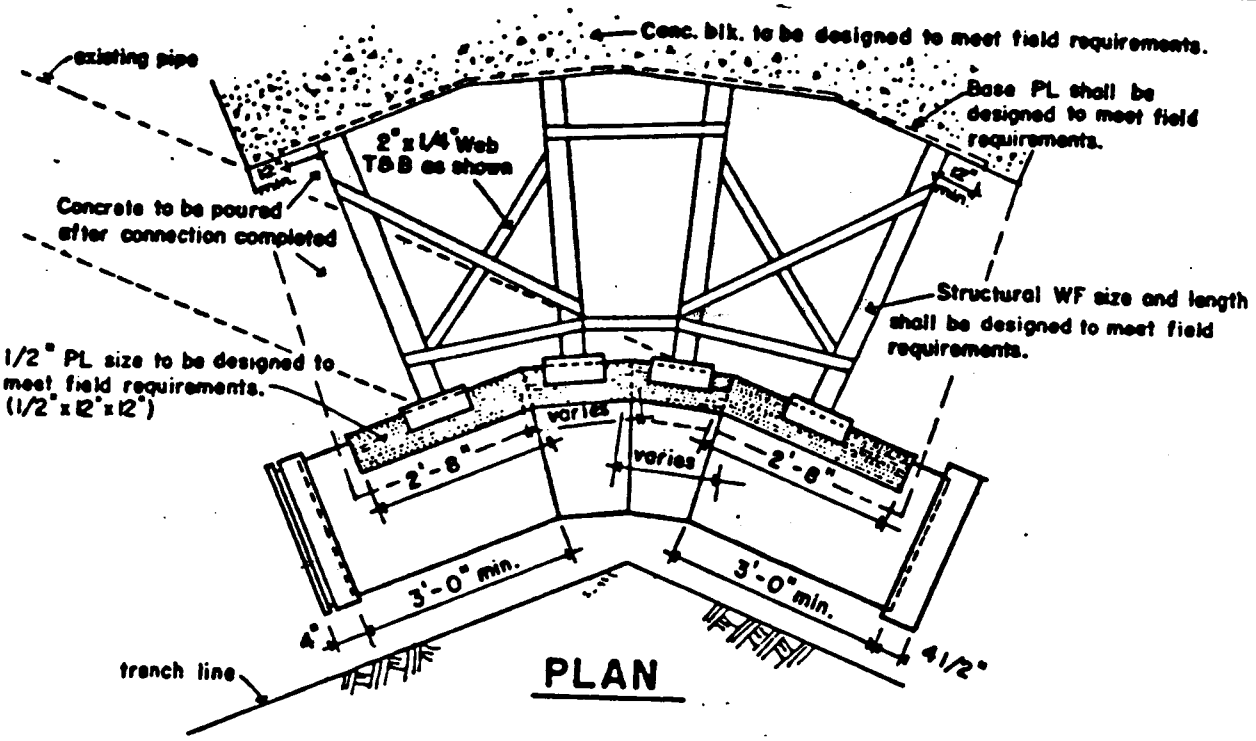
TYPICAL THRUST BLOCK PLATE
22 1/2° - 45° CONCRETE CYL. BEND
FOR CONNECTIONS ONLY 16"-42"

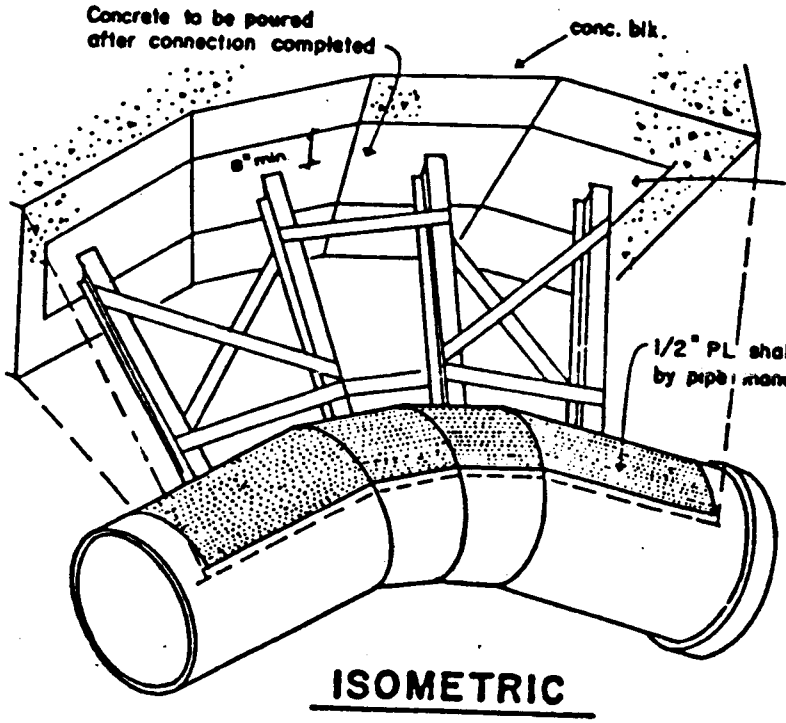
SCALE: NTS

STANDARD DETAILS

112

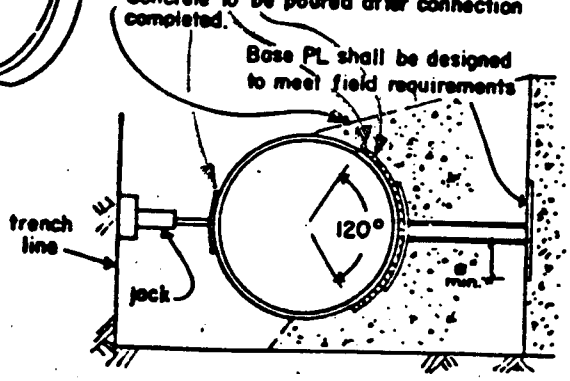


PLAN



ISOMETRIC

1/8" MAX. THICK SHEET GASKET RUBBER TO BE INSTALLED BETWEEN THE PIPE AND STEEL PLATE (OAHU ONLY)



SECTION

NOTES:

1. All welds shall conform to AWS standards
2. PL shall be uncoated ready to receive thrust struts and appurtenances.
3. Deliver at request.
4. Number of struts to be used may vary according to working pressure.

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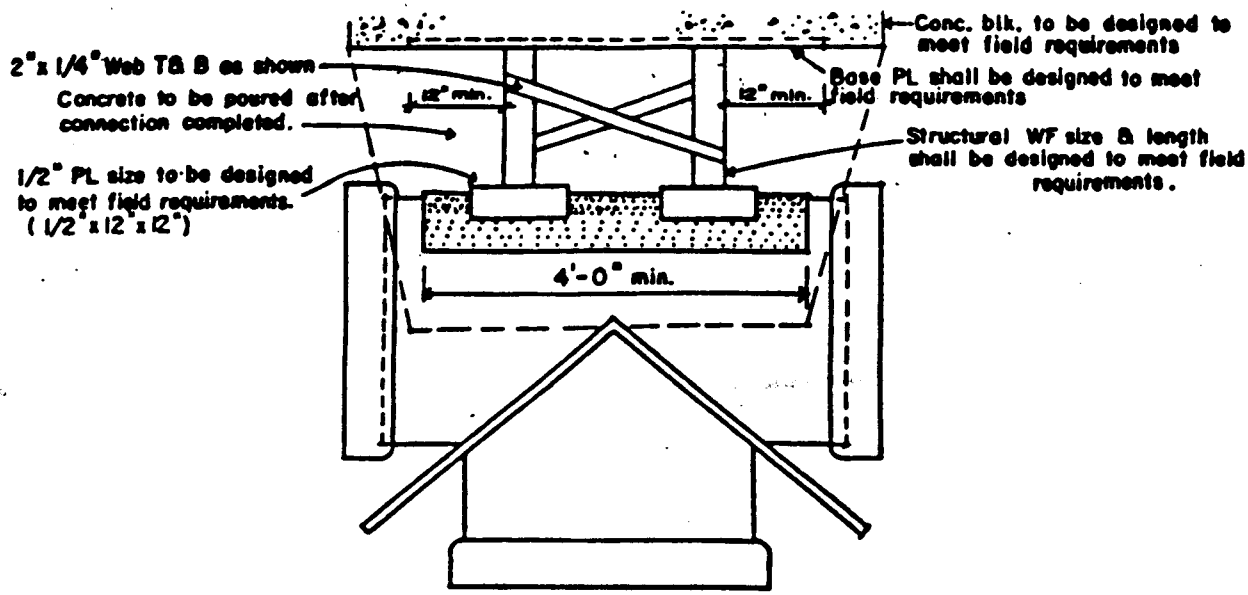
TYPICAL THRUST BLOCK PLATE
45°-67 1/2° CONCRETE CYL. BEND FOR CONNECTIONS ONLY 16"-42"

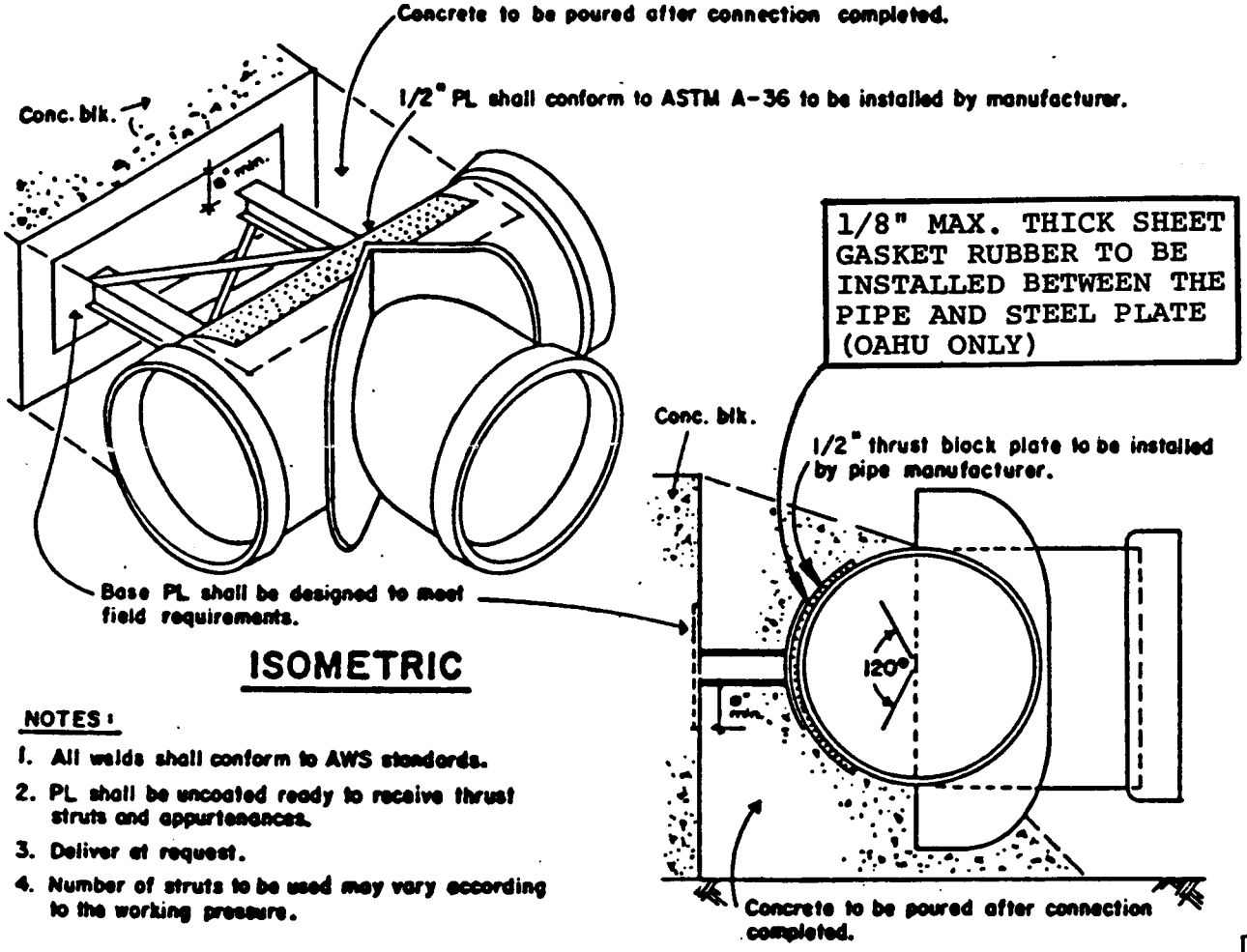
SCALE: NTS

STANDARD DETAILS

113



PLAN



ISOMETRIC

SECTION

NOTES:

1. All welds shall conform to AWS standards.
2. PL shall be uncoated ready to receive thrust struts and appurtenances.
3. Deliver at request.
4. Number of struts to be used may vary according to the working pressure.

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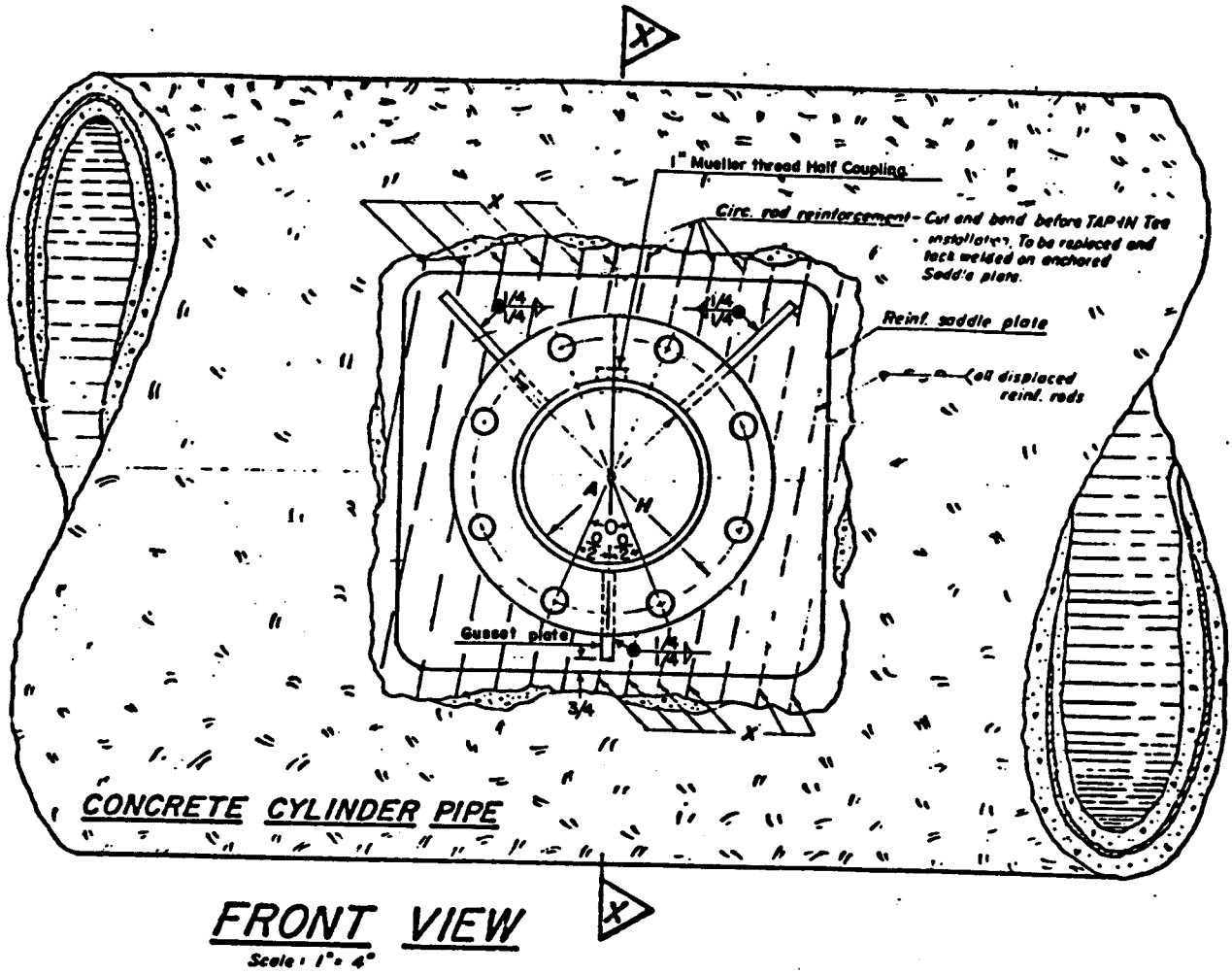
KAUAI OAHU MAUI	**TYPICAL THRUST BLOCK PLATE** **CONCRETE CYL. TEE CONNECTION (16"-42")** SCALE: NTS	STANDARD DETAILS	114



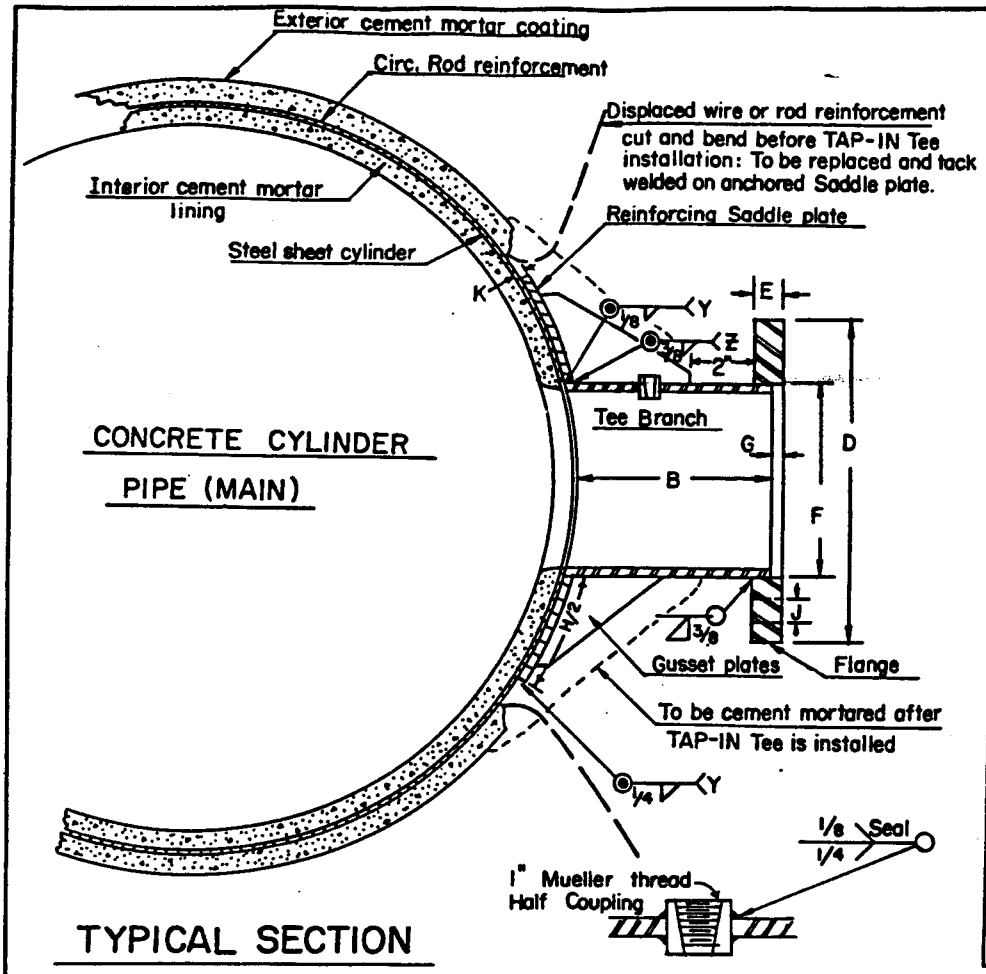
FRONT VIEW

Scale: 1" = 4'

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS FOR ISOLATION REQUIREMENTS (OAHU ONLY)

KAUAI OAHU MAUI	CONCRETE CYLINDER PIPE TAP-IN TEE SCALE: NTS	STANDARD DETAILS	115

1991
1985
REVISION



DIMENSIONS (inch) TEE BRANCH							
	Nominal Branch Size (dia.)	4	6	8	12	16 *	
A	Actual Branch Diameter (I.D.)	4.25	6.25	8.375	12.375		
B	Length of Tee Branch	6.00	6.00	6.25	6.25		
C	Min. Thickness of Tee Nipple	0.237	0.280	0.280	0.330		
D	Diameter of Machined Flange	9.125	11.125	13.656	19.00		
E	Flanged Thickness	0.94	1.00	1.125	1.25		
F	Flange Offset Diameter	4.724	6.81	8.935	13.035		
G	Depth of Flange Offset	0.375	0.375	0.375	0.375		
H	Bolt Circle Diameter	7.50	9.50	11.75	17.00		
J	Amount & Dia. of Bolt Holes	(8)0.750	(8)0.875	(8)0.875	(12)1.00		
K	Thickness of Reinf. Saddle Plate	0.250	0.250	0.250	0.375		
O	Degrees Between Bolt Center	45°	45°	45°	30°		

* For 16" and larger Branch the contractor shall submit 6 sets of Shop drawings for approval by the water department.

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS FOR ISOLATION REQUIREMENTS (OAHU ONLY)

FABRICATION NOTES

1. All TAP-IN Tee componets shall be made from new and sound materials as specified.
2. Steel products for components shall be hot rolled M-1020 or better.
3. Welding electrodes shall meet ASTM A-223, AWS A-5.1 Specifications.
4. The top two bolt holes on the flange shall be equidistant from the plumb center line.
5. The butt end on the branch and the arch on the reinforcing saddle plate shall conform to the O.D. of the steel sheet cylinder so that a tight and close fit joint will be attained on the steel sheet cylinder. Diameter of branch hole on the saddle plate is 0.50" larger than the O.D. of the branch.
6. Three 0.375" thick gusset plates shall be provided and installed in the field.

INSTALLATION PROCEDURE

1. Remove sufficient exterior mortar coating from Concrete Cylinder pipe to contain Reinforcing Saddle plate.
2. Position and mark out exact outline of Reinforcing Saddle plate on exposed steel sheet cylinder.
3. Tack weld circumferential wire or rod reinforcement onto steel sheet cylinder - 1" away from perimeter of saddle plate
4. Cut and bend reinforcing wires or rods away from the work area.
5. Position and draw Reinforced Saddle plate tightly against the steel sheet cylinder before welding the Saddle plate on the cylinder, as indicated by "Y".
6. Tee Branch installation :
   - A. Position the preshaped end of the Tee Branch on the steel sheet cylinder through the branch hole on the Saddle plate.
   - B. Weld the Branch to the steel sheet cylinder before joining and tying the Branch to the Saddle plate, as indicated by "Z" on SECTION X-X.
   - C. Fit and install the gusset plates, as above.
   - D. Test welded joints on new installation for leaks.
   - E. Bend and replace the displaced circumferential wire or rod reinforcement over the Saddle plate and tack weld the wires or rods to the plate.
   - F. Apply a heavy coat of cement mortar on exposed metal surface, as shown by dotted lines on SECTION X-X.

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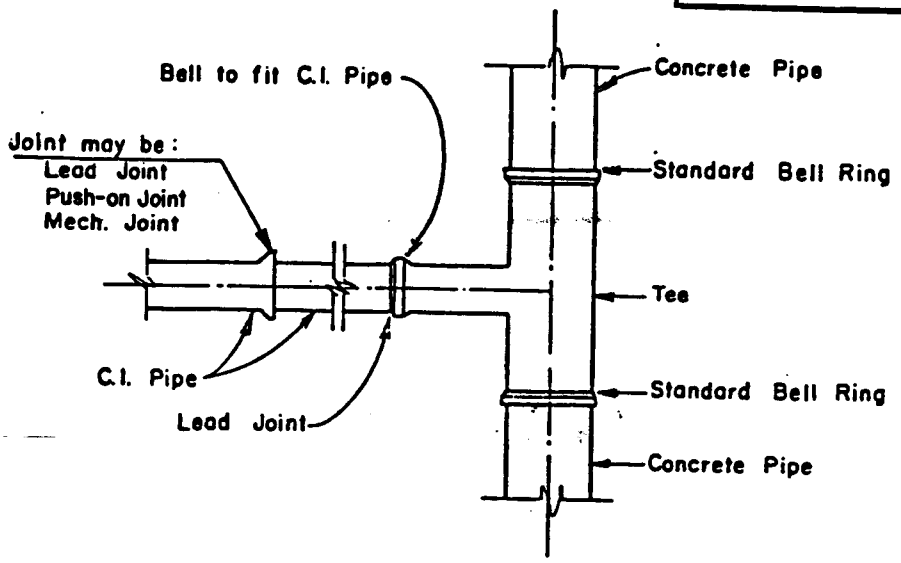
CONCRETE CYLINDER PIPE TAP-IN TEE DETAILS

SCALE : NTS

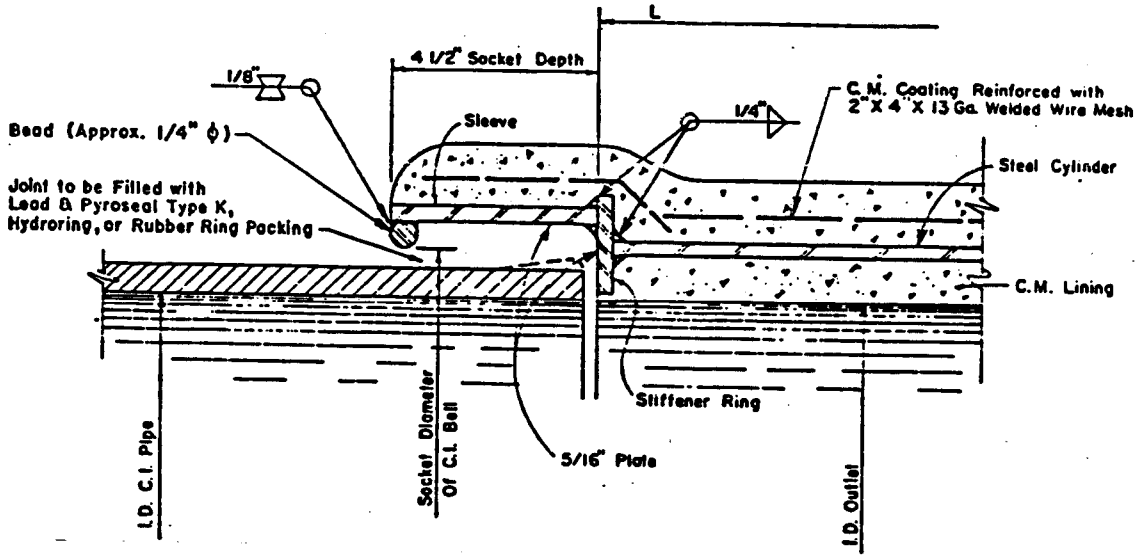
STANDARD DETAILS

116

SEE TABLE 4, VOLUME 3 OF WATER SYSTEM STANDARDS (OAHU ONLY)



TYPICAL CAST IRON PIPE CONNECTION TO CONCRETE CYLINDER PIPE



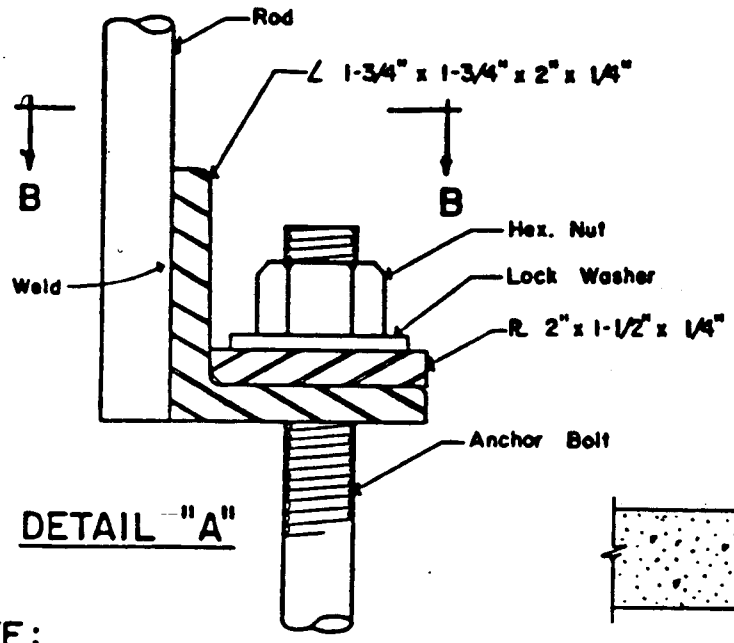
DETAIL OF C.I. ADAPTER

KAUAI OAHU MAUI	**CONCRETE CYLINDER PIPE** **MISCELLANEOUS DETAILS** SCALE: N.T.S.	STANDARD DETAILS	121

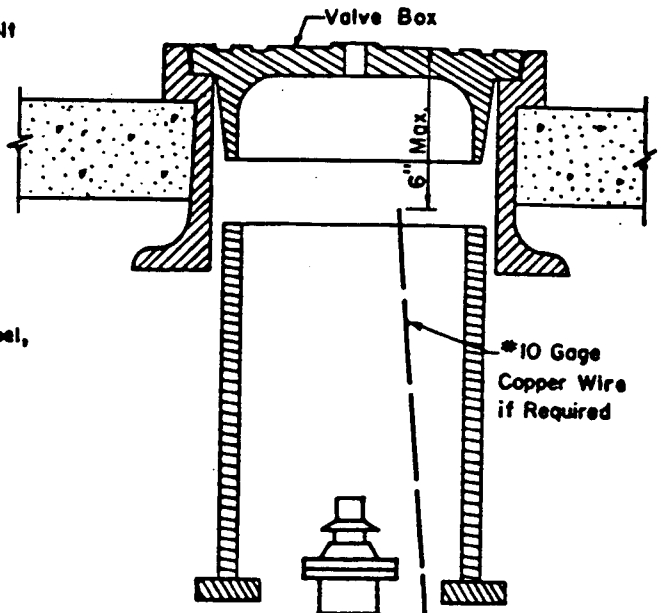
1991
1985
REVISION

SEE TABLE 3 VOLUME 3 OF WATER SYSTEM STANDARDS (OAHU ONLY)

THE STRAPS AND ANCHOR BOLTS SHALL BE BRONZE OR STAINLESS STEEL (OAHU ONLY)

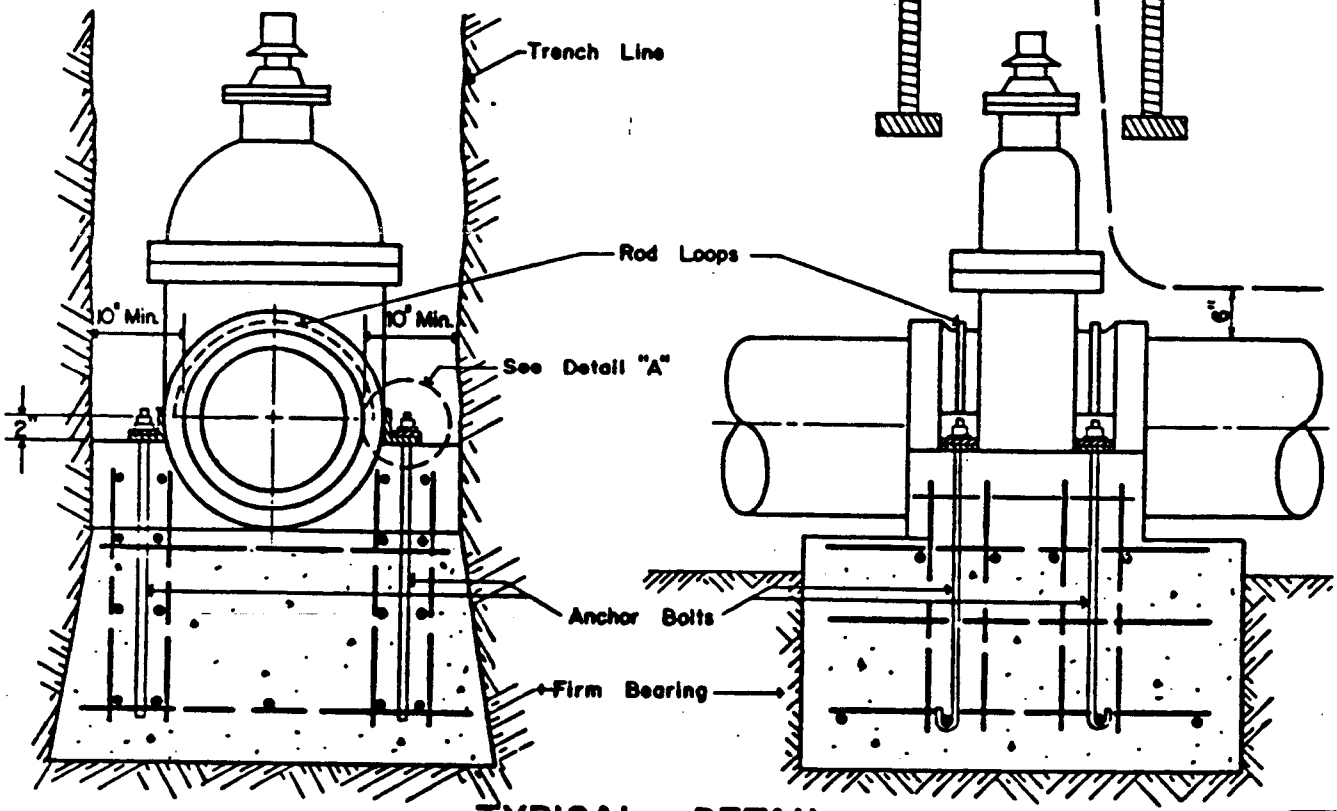


DETAIL "A"



NOTE:

1. Apply bond breaker between gate valve and concrete.
2. All anchor materials shall be shop galvanized steel, and coated with asphaltic material after installation.
3. 3" clearance for all reinforcing steel.
4. Detail of actual block shall be furnished by the contractor/engineer.



TYPICAL DETAIL
(FOR VALVES 12" & UNDER)
NOT TO SCALE

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OAHU MAUI	GATE VALVE ANCHOR BLOCK FOR AC AND PVC PIPE SCALE : NTS	STANDARD DETAILS	122