Technical Report Documentation Page

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3. RECIPIENT'S CATALOG No.

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A Report on the Investigation of the Corrosion of the Underground Piping System at the California Air National Guard Base, Fresno, California

5. REPORT DATE
May 1961

6. PERFORMING ORGANIZATION

7. AUTHOR(S)
Stratfull, R.F.; Maxwell, W.S.; and G.R. Steffens

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Service Agreement S.A. 2337

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Department of Public Works
Division of Highways

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

I. Introduction and History

On December 19, 1960, Mr. A. Louargard, Supervising Electrical Engineer, Division of Architecture, requested by letter that the Materials and Research Department perform a corrosion survey of the underground piping installations at the California Air National Guard Base at Fresno, California, under Inter-Agency Agreement S.A. 2337 and Work Order 4338GC-1. It was requested that recommendations be submitted for minimum control of the underground pipe installations at this base.

Historically, the California Air National Guard Base was constructed approximately six years ago. During this period one leak in the water pipe was repaired in February 1961.

A corrosion study was made by representatives of the Materials and Research Department during the month of March 1961. The results of the corrosion survey are included in this report.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A REPORT ON THE INVESTIGATION OF THE CORROSION OF THE UNDERGROUND PIPING SYSTEM AT CALIFORNIA AIR NATIONAL GUARD BASE, FRESNO, CALIFORNIA

DND 61-01

MAY 1961

MATERIALS & RESEARCH DEPARTMENT

State of California
Department of Public Works
Division of Highways
Materials and Research Department

May 1961

Inter-Agency Agreement
Service Agreement S.A. 2337
W. O. 4338GC-1
Lab. Auth. Proj. 72-S-6240

Mr. Anson Boyd
State Architect
Division of Architecture
Sacramento, California

Attention: Mr. O. E. Anderson, Principal Engineer

Dear Sir:

Submitted for your consideration is:

A REPORT ON

THE INVESTIGATION OF THE CORROSION OF

THE UNDERGROUND PIPING SYSTEM AT

CALIFORNIA AIR NATIONAL GUARD BASE

FRESNO, CALIFORNIA

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work supervised by . . . . R. F. Stratfull
Report prepared by R. F. Stratfull, W. S. Maxwell, G. R. Steffens

Very truly yours,

F. N. Hveem
Materials and Research Engineer

By

J. L. Beaton
Supervising Highway Engineer

RFS/WSM/GRS:mw
cc: Fresno Air Natl. Guard (3)
Div. of Arch. (6)
L. R. Gillis
District VI

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I. INTRODUCTION AND HISTORY

On December 19, 1960, Mr. A. Louargand, Supervising Electrical Engineer, Division of Architecture, requested by letter that the Materials and Research Department perform a corrosion survey of the underground piping installations at the California Air National Guard Base at Fresno, California, under Inter-Agency Agreement S. A. 2337 and Work Order 4338GC-1. It was requested that recommendations be submitted for minimum control of the underground pipe installations at this base.

Historically, the California Air National Guard Base was constructed approximately six years ago. During this period one leak in the water pipe was repaired in February 1961.

A corrosion study was made by representatives of the Materials and Research Department during the month of March 1961. The results of the corrosion survey are included in this report.

II. SUMMARY AND CONCLUSIONS

The soil at this site is a sandy silt and is considered to be relatively non-corrosive. The soil was measured and found to have an average pH of 7.8 and average resistivity of 2800 ohm-cm. These values indicate a 3/4" bare steel pipe should resist penetration by corrosion for approximately 37 years.

The perforation of the 2½" water line between the warehouse and hangar appears to be caused by the underground pipe being electrically connected to the concrete embedded steel in the building.

The Rocket Building has a massive underground electrical grounding network that is constructed of copper. All of the underground steel pipe that is electrically connected to this grounding network is corroding at a rapid rate. It is anticipated that sections of the steel pipe may have to be abandoned within 5 years if corrosion control measures are not undertaken within the near future. Corrosion control may be accomplished by the use of cathodic protection.

Before cathodic protection is applied, all underground pipe should be electrically insulated from all buildings and grounding systems. Jumper wires should be installed where necessary to make the underground piping system electrically continuous.

After the installation of the cathodic protection system, periodic operational checks should be made by trained personnel. These personnel can be trained by the Materials and Research Department. It cannot be emphasized too greatly that a cathodic protection system of this nature should be periodically checked. The reasons are (1) that it will not control the corrosion of the pipe if not properly adjusted and (2) there is a possibility that the electrical cathodic protection could corrode underground pipe both on and beyond the limits of the site. This could occur because of an electrical discontinuity in the existing pipe or by the installation of new metallic pipe not electrically bonded to the cathodic protection system.

Written instructions for measuring the pipe to soil potential are included in the Appendix of this report.

III. RECOMMENDATIONS

A. General

1. Plans and specifications for the cathodic protection system be considered tentative until additional tests as outlined in "Corrosion Control, Phase II" of the Appendix are completed. Price estimates are to be used for budget purposes only.

2. That the installation of the cathodic protection system be accomplished in three phases (see Appendix).

3. The Division of Architecture prepare the final plans, specifications and field inspection of the cathodic protection system.

4. Where necessary, install a separate grounding system for the building facilities. Do not ground electrical facilities to hose bibs or any sections of underground pipe.

5. Within 30 days of the termination time of contract, the contractor shall notify in writing all major utility companies in the area of the State's intentions to cathodically protect the underground pipe.

IV. TESTS

A. Pipe to Soil Measurements

Pipe to soil potentials were measured on all of the electrically continuous gas, water, and air lines. Exhibit VI. Equi-Potential Contour Plan, shows the general areas in which future leaks will occur. It should be noted that the area in which the past leak occurred, between the hangar and warehouse, is also a future leak area.

B. Electrical Resistivity of the Soil

The electrical resistivity of the soil at the California Air National Guard Base is shown on Exhibit V, Equi-Resistivity Contour Plan. As indicated by the resistivity measurements, the soil varies from 1600 ohm-cm to 5200 ohm-cm. The resistivity of the soil at the leak area is a moderately corrosive soil which is approximately 1600 ohm-cm. However, the leak is not the result of soil action but as a result of its connection to the buildings (see Discussion).

C. Miscellaneous Tests

1. Electrical continuity tests were performed on all metal underground piping. No points of discontinuity were found during this phase of investigation.

2. A preliminary field test was performed on electrically isolated sections of coated and also uncoated pipe to determine the cathodic protection current requirements. The tests indicated that it will take approximately 2 to 3 milliamperes per sq. ft. to obtain cathodic protection. However, the installation was designed for a 5 milliamperes per square foot current requirement, as it was reported and observed that the coating on the pipe may be in a more adverse condition than those sections which were tested.

3. Water. A sample of the water used at the facility was taken. The results of the partial laboratory tests are as follows: pH 7.5, resistivity 2200 ohm-cm. By means of an empirical test, it is estimated that a 3/4" steel pipe may be perforated by internal corrosion in approximately 30 years.

4. Soil. Field tests show that the average resistivity of the soil at the Air Guard installations is about 2800 ohm-cm and the average pH is 7.8.

By means of an empirical soil test it is estimated that a 3/4" steel pipe placed in this soil would be perforated by corrosion in approximately 37 years, providing there are no accelerating causes of corrosion.

V. DISCUSSION

A. Cause of Corrosion

1. Electrical Interconnection of Underground Structures.

   Field tests indicate that the water, gas, and air lines are electrically connected to the concrete embedded steel in the buildings and underground copper grounding systems. A flow of current from the underground pipes through the soil to the buildings was detected by electrical measurements. These measurements indicate that the concrete embedded steel and copper grounds are cathodic and causing the corrosion of the underground pipe system. This is shown on Exhibit VI, Equi-Potential Contour Map. Steel in concrete becomes passive (more noble) and is caused to be electrically equivalent to copper. The electrical interconnection of concrete embedded steel to steel placed underground will cause accelerated corrosion and failure of the underground metal pipe.

   Electrical measurements taken on the 4" gas line between the Air Guard buildings and runways indicate a direction of current flow in the pipe from the Flight Simulator Building towards the Rocket Storage Building. Also, there is a measurable current flow from the Wing Group Building to the Rocket Storage Building. This flow of electrical current in the gas pipe in the direction of the Rocket Storage Building is the result of electrical connection of the copper grounding system in the Rocket Storage Building and the underground pipe. Being a more noble metal, the copper causes a galvanic corrosion cell to form and will cause failure of the steel piping system. The direction of current flow is shown by the direction of the measured voltage drop on Exhibit VI, Equi-Potential Contour Map.

B. Electrical Insulation

1. Before the installation of the cathodic protection system, the underground pipe must be electrically disconnected from the concrete embedded steel and the copper mesh beneath the Rocket Storage Building. Otherwise, the cost of the cathodic protection will probably increase by a factor of 500%. It will be necessary to insulate the gas and water lines where they enter the Rocket Storage building. These lines may be electrically connected to the copper mesh at some point away from the building, since the mesh extends 10' - 15' beyond the limits of the building. This could be determined after completion of Phase II of the Appendix. If the gas line is in contact with the copper mesh, it would most likely be more economical to replace this short section of gas pipe.

2. The 6" section of cast iron water line on the north side of the Wing Group Building should be insulated from other underground pipe by electrically disconnecting it from the pipe which services the Wing Group Building. If it is connected to the cathodic protection system, this cast iron pipe will require electrical bonding at each joint. This is not considered to be economically feasible.

3. The 4" gas line feeding the Air Guard installation and running adjacent to Dutch Mill Road shall be placed under cathodic protection from the facility to the reducing valve located approximately 3/4 mile west of the JP-4 fuel tanks. The reducing valve shall be insulated at this point in order that current may be kept within the limits of the National Air Guard installations, otherwise the cathodic protection system may protect all of the underground pipe in the City of Fresno.

4. Install insulators in the Wing Group Building area as noted on Exhibit V, Note #4, in the following manner:

   Step 1. Install an insulator inside of the building on the building supply water line at the point of entry.

   Step 2. If tests indicate the building is not insulated from the underground pipe, then install an insulator on the building water supply line at the point of entry outside the building.

   Step 3. If further tests indicate the building is still not electrically insulated from the underground piping, it will be necessary to install insulators on the 3" main water line that passes beneath the building at the points where the pipe enters and leaves the building's concrete footings. The pipe may be electrically connected to steel in the footing.

   Step 4. If Step 3 is performed, it is possible that leaks will occur on the 3" water main passing under the building, therefore, it will be necessary to replace this section of 3" water main.

5. Insulating Coupling Unit (I.C.U.)

   An I.C.U. should be installed at each underground insulator since it is used as a checking point to determine the efficiency of the insulator.

   The I.C.U. consists of two #8 C.P. wire leads electrically bonded (welded or brazed) on each side of the insulator.

The other ends of the leads are extended to a ground mounted concrete pull box. The wire leads are not to in electrical contact with each other.

C. Cathodic Protection

1. The use of cathodic protection for protecting underground metals is a common engineering practice. It is probable that a few leaks will appear in the piping soon after the application of cathodic protection. The reason for the occurrence of "new" leaks is that the pipe may be so corroded that the corrosion products are acting as a temporary "plug". When cathodic protection currents are applied, hydrogen gas will be evolved on the surface of the pipe. This gas will originate between the metal surface and the rust, and the rust will be mechanically loosened due to the formation of the gas. If the rust is acting as a "plug", the loosening of this rust plug will result in a leak in the pipe. Also, movements of the soil resulting from variations in moisture content can loosen the "plug", and the resultant leak will be noticed.

If a leak is found in the piping system near a pipe joint, or other pipe, it is good field practice to electrically bond the pipe sections together as a standard repair procedure. Also, at the conclusion of the installation of the anodes and before the application of cathodic protection, the piping system should be again checked for electrical continuity.

Two separate impressed current cathodic protection systems are considered to be adequate for the facility and their contemplated locations as noted on Exhibit V, Equi-Resistivity Contour Plan. One system will be used to protect all continuous underground metallic piping, the 5000 gallon gasoline tank located adjacent to the Motor Service Shop, the 5000 gallon fuel oil tank located next to the hangar. A magnesium anode facility can protect the isolated sprinkler system at the east end of the Air Guard facilities. A separate cathodic protection system will protect the four underground 25,000 gallon JP-4 aviation fuel tanks located to the west of the Wing Group Building. However, the use of two cathodic protection systems is contingent upon the tests made at the conclusion of the work outlined in Corrosion Control, Phase II.

2. Bonds and Jumpers

   a. Bonds are short lengths of #8 C.P. wire (3' or less) used to make an electrical connection between the intersection of two metal pipes.

   b. Jumpers are long lengths of #8 C.P. wire (5' or more) used to electrically interconnect underground pipe to the cathodic protection system.

VI. APPENDIX

A. Corrosion Control

The protection of the underground piping facilities shall be accomplished in three phases as follows:

Phase I

1. Electrically insulate all underground water, air, and gas lines from the buildings at the following locations:

   a. At the soil side of the buildings where any pipe enters the buildings.

   b. At all connections of copper to steel pipe.

   c. At all connections between State piping and those of private utilities.

   d. At union of 6" cast iron water main and 3" galvanized steel lines that service the Wing Group Building.

   e. On the Air Guard side of the 4" gas line reducing valve located approximately 3/4 mile west of JP-4 fuel tanks on Dutch Mill Road.

2. Except for isolated section of pipe at the east end of the Air Guard facilities as noted on Exhibit V, all other isolated sections of pipe and the isolated 5000 gallon gasoline and oil tanks be electrically bonded to the main underground piping system by jumper wires in order that all underground metallic pipe and structures be placed under protection.

Phase II

1. Perform field tests to determine size of rectifiers and anode beds.

2. Perform tests to verify the continuity of the piping.

3. Perform tests to verify the electrical isolation of the pipe from the buildings and other underground facilities.

Phase III

1. Install rectifiers and anode beds as determined by testing conducted at conclusion of Phase II.

2. After installation of rectifiers, perform additional field tests and make the necessary rectifier adjustments.

3. Install the single magnesium anode and jumper wires for the remote sprinkler pipe as noted on Exhibit V.

4. Install any additional insulators or jumpers that may be located during Phase II.

5. Determine locations of and install permanent test locations for monitoring the operation of the cathodic protection system after the system has been in operation for approximately one month.

B. <u>Future Work</u>

1. Maintenance

a. If the cathodic protection system is not checked periodically, that the corrosion control measures be abandoned.

b. A standard copper sulfate half-cell and a high resistance millivoltmeter be purchased by the Air Guard so that the maintenance personnel (who have been trained) may make the necessary monthly checks on the operation of the system.

c. Take monthly pipe to soil potentials at locations determined after Phase III of the installation has been completed.

d. That an over-all pipe to soil potential, survey and electrical continuity be made between 30 days and six weeks after the installation of the new cathodic protection system and once a year thereafter.

2. Future Construction of Underground Pipe System

a. When new metallic pipe is to be installed, the influence of this pipe on the cathodic protection system be determined, and, if necessary, the rectifier output be adjusted.

b. No new piping in the same excavation shall lie across or otherwise be in mechanical or electrical contact with other pipe except at designated locations.

c. If cast iron pipe is to be used as gravity flow lines, electrically disconnect it from all other piping.

d. If cast iron pipe is to be used as pressure lines, electrically bond each joint by means of brazing or welding and place under cathodic protection.

e. All future underground piping shall be new pipe coated with coal tar enamel which is covered by AWWA Specification C203 together with Section A1.2 of the Appendix of said specification or with a 20 mil film thickness of polyethylene or polyvinyl chloride tape coating.

f. That any new piping installed underground at this site be non-metallic where it is mechanically feasible.

C. Method for Measuring Pipe to Soil Potentials

Monthly cathodic protection potential readings must be obtained and recorded so that any erratic changes noted in the system can be investigated and, if necessary, corrected.

Readings are obtained by conducting a pipe to soil potential survey using a high resistance voltmeter and a standard copper sulfate half-cell.

A high resistance voltmeter is used to obtain adequate sensitivity. The copper sulfate half-cell is used as a stable reference point as it has a constant unchanging electrical voltage. The voltmeter measures the electrical voltage difference between the pipe and the copper sulfate half-cell.

Use the following procedure for conducting a pipe to soil survey:

1. Attach positive (+) lead from voltmeter to copper sulfate half-cell.
2. Attach negative (-) lead from voltmeter to pipe being checked.
3. Wet ground at check point.
4. Place copper sulfate half-cell on wet ground at check point.
5. Read and record voltage.

A record of all readings should be kept and and discrepancies in the system be brought to the attention of the corrosion engineer. Readings can be recorded as shown on Exhibit I.

D. Equipment for Pipe to Soil Potential Survey

Simpson Model 269 AC-DC Volt-Ohm Microammeter 100,000 ohms/volt DC, 5,000 ohms/volt AC, w/carrying case	$ 99.50
8" copper sulfate half-cell (J. L. Collins Co., Angleton, Texas)	11.00
Cupric Sulfate-Fine Crystal Reagent (1 pound)	1.25
	$ 111.75

E. Copper-Sulfate Half-Cell

1. Preparation of Solution:

The copper sulfate half-cell contains a solution that is made from crystals of cupric sulfate and water. The amount of each used to charge the half-cell is as follows:

a. Pour enough cupric sulfate crystals into the half-cell to fill the cell to a height of 1 inch or more above the bottom of the cell.

b. Add enough distilled water to fill the cell to within ½ inch of being full.

c. Screw the cleaned copper electrode into the cell and allow to stand overnight before using.

2. Maintenance of Half-Cell:

When the half-cell is not in use, the wooden tip should be kept clean and covered with the rubber cap to maintain long life.

At the time of each monthly measurement, the half-cell should be emptied and then refilled with a new solution. The copper rod should be cleaned to a bright appearance with sandpaper to remove the copper oxide coating on the copper rod. Before inserting the copper electrode into the cell, wash the rod with distilled water to remove any dirt, etc.

CAUTION: The cupric sulfate crystals are poisonous. Wash hands after using the half-cell and the cupric sulfate crystals.

F. Suggested Specifications

I. Impressed Current Protection

Rectifier:

Good-All Add-A-Stack Y36-24 selenium rectifier or equal. The output shall be variable from 0 to the maximum voltage in a minimum of 10 equal steps.

The rectifier shall perform satisfactorily at maximum output at an ambient temperature of 130° F. The unit shall have built-in input and output overload protection.

A D.C. ammeter with suitable range switching shall be installed. The scale ranges of such an ammeter will not exceed 140% of the rated output reading of each selenium stack.

The entire installation shall be mounted in a vandal-proof enameled steel box of code gauge thickness. The box shall have a locking cover and padlock, and it shall be suitable for wall or bench mounting.

Anodes:

The impressed current anode shall be "Durion" 2" x 60" Type D-LO high silicon cast iron anodes, or equal high silicon cast iron anodes with five feet of A.W.G. #8 oil resistant waterproof cable or equal.

Anode Backfill Materials:

The anode backfill material shall be Coal Coke Breeze graded to #8 mesh particle size with less than 10% dust content.

Installation of Anodes:

Impressed current anodes shall be placed at the designated locations in the following manner:

1. Auger or otherwise construct an anode hole of 10" in diameter 10' below grade.

2. Fill bottom of hole with special backfill material to a compact depth of 1', which is 9' below grade.

3. Center anode carefully in hole and add backfill material in one foot compacted layers until the backfill is approximately one foot above anode.

4. After making electrical connections, backfill the remainder of the hole with sand. Top soil may be used in the top six inches.

Wiring:

Standard copper anode lead wire shall be C.P.S. OR-1 600 volt A.W.G. #2/0 or Anaconda Type CP cathodic protection cable or equal.

All "in line" splices and all splices of the anode lead wires to the feeder lines shall be made with the Cadweld process or equal.

All underground wire splices shall be adequately protected from current leakage through the soil by using a Scotch-Cast Splicing Kit containing No. 4 resin or equal.

The main feeder wire from the rectifier to the anode beds and pipe shall be buried at least two and a half feet below the original ground or at a depth which will insure protection of the wire from accidental severance by cultivation or excavation.

The main feeder wire from the rectifier to the anode beds and pipe shall be encased in conduit to the depth of burial of the wire. The length of conduit shall be sufficient to protect the feeder wire from tampering or accidental severance and will traverse the distance between the rectifier and that point where the wire is buried at specification depth.

Jumper Wire Installation:

Do not weld or braze jumper wires to gas pipes. Weld or braze the jumper wire to clamp and then mount the clamp on the gas pipe.

Weld or braze jumper wires to all water lines.

Suggested Cathodic Protection Material Suppliers:

Harco Corporation
P. O. Box 7026
16901 Broadway Avenue
Cleveland 28, Ohio

Electrical Facilities, Inc.
1307 66th Street
Emeryville, California

Frost Engineers Service Co.
P. O. Box 767
Huntington Park, California

The Pipeline Protection Co.
420 Market Street
San Francisco 11, Calif.

Brance Kracky Co.
4411 Navigation Blvd.
Houston, Texas

Pipe Line Anode Corp.
Box 996
Tulsa, Oklahoma

Pipeline Coating & Eng. Co.
5501 South Santa Fe
Vernon, California

Vanode Corporation
880 East Colorado St.
Pasadena 1, California

II. Galvanic Protection

Sacrificial Anodes - Galvanic

Dow Type 32-D galvo-pak (Galvo-Mg) magnesium anodes with 15 foot length of lead wire.

a. Placement of Anodes and Shunt

1. Place anode from 5' to 10' from the pipe and auger 8" diam. hole 5' 6" deep.

2. Place anode in hole and compact soil around and to the top of the anode so that the anode is firmly contacting soil on all sides.

3. Moisten anode with water until air bubbles cease to rise to the surface of the water.

4. A shunt metering box is placed near the pipe and installed level with the grade as noted on Exhibit I.

b. Excavate trenches 12" deep by 3" (min.) wide from anode to gas pipe for placement of the anode lead wire.

NOTE: The electrical connection of the magnesium anode lead wire to the pipe will automatically result in a flow of electrical current. The magnesium anode will be inside a cloth sack and surrounded by a special backfill material. (Do not open or cut the cloth sack; embed the entire unit in the anode hole.)

Miscellaneous:

Materials can be purchased from the following companies:

Anodes

Cathodic Protection Service
4601 Stanford Street
Houston 6, Texas

The Pipeline Protection Co.
420 Market Street
San Francisco 11, Calif.

Ground Clamp & Shunts

Pipeline Coating & Engineering Co., Inc.
5501 South Santa Fe Street
Vernon, California

Pull Boxes

Brooks Products, Inc.
2400 Adeline Street
Oakland, California

G. Cathodic Protection Cost Estimate

Item	Quantity	Unit Cost	Materials Total Cost	Hours Labor
Good-All "Add-A-Stack" Rectifier Y36-24 - 4 stack	1 each	$1050.00	$1050.00	8
" 1 stack	1 each	775.00	775.00	4
Anodes - Durion (2"x60")	29 each	18.00	522.00	58
(Coke Breeze) Backfill	7250 lbs.	45/ton	163.00	87
#2/0 Type CP-600 volt AWG	1370 ft.	370/M	506.90	45
Misc. Elect. Material	L. S.		50.00	16
Trencher Rental	L. S.		100.00	
Trench Excavation	1350 ft.	20¢/ft.	270.00	54
Misc. Excavation	L. S.		110.00	20
Holes Excavated	29 each	3.00	87.00	18
#8 CP Wire - Bonds	33 each	5.00	165.00	66
#8 CP Wire - Jumpers	8 each	5.00	40.00	16
Scotch Cast Splicing Kits 82-A2 with #4 Resin (Wye)	27 each	6.50	175.50	27
Scotch Cast Splicing Kits 90-B1 with #4 Resin (in line)	2 each	5.50	11.00	2
Ground Clamps (Gas Pipes)	9 each	1.00	9.00	16
1½" Conduit	50 ft.	80¢/ft.	40.00	8
Pro-Seal EP 711	8 lbs.	5.00	40.00	20
3/4" to 3" Insulating Couplings	41 each	20.00	820.00	656
3" to 4" Insulating Couplings	10 each	30.00	300.00	180
Insulator Check Unit	4 each	10.00	40.00	8
Type 32-D Galvo-Pak Anode ave. wt. 80#, rating 2 amp years	1 each	21.50	21.50	3

Item	Quantity	Unit Cost	Materials Total Cost	Hours Labor
#3½ State pull box or equal (Conc. Box w/conc. cover)	1 each	$ 5.60	5.60	1
0.01 ohm metering shunt	1 each	0.60	0.60	
Cathodic Protection Check Point Markers	12 each	2.50	30.00	18

Total Materials Cost		$ 5,332.10	
Sales Tax 4%		213.28	
Labor Cost @ $5.00/hr.		6,655.00	
Insurance @ 12½% of labor		831.88	
Sub-Total		13,032.26	
20% Profit and Overhead		2,606.45	
Engineering and Inspection		3,000.00	
State furnished equipment			
Volt-ohm-microammeter	1 each	99.50	
8" Copper Sulfate Half-Cell	1 each	11.00	
Cupric Sulfate Crystals	1 lb.	1.25	
Total Cost		$ 18,750.46	say $ 19,000.00

EXHIBIT I

RECTIFIER AND CHECK POINT RECORD

Cathodic Protection Record For ______________________ 19 ____

		Volts	Amps
Rectifier No.	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________

		*P/S at Present Rectifier Setting	*P/S After Rectifier Setting
Check Point No.	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________

			Volts	Amps
Rectifier No.	____	Readjusted to	________	________
	____		________	________
	____		________	________
	____		________	________
	____		________	________
	____		________	________
	____		________	________

NOTE: Settings to be changed only if a particular check point shows that the pipe in that area is less than 0.85 volts.

* P/S Pipe to Soil Potentials

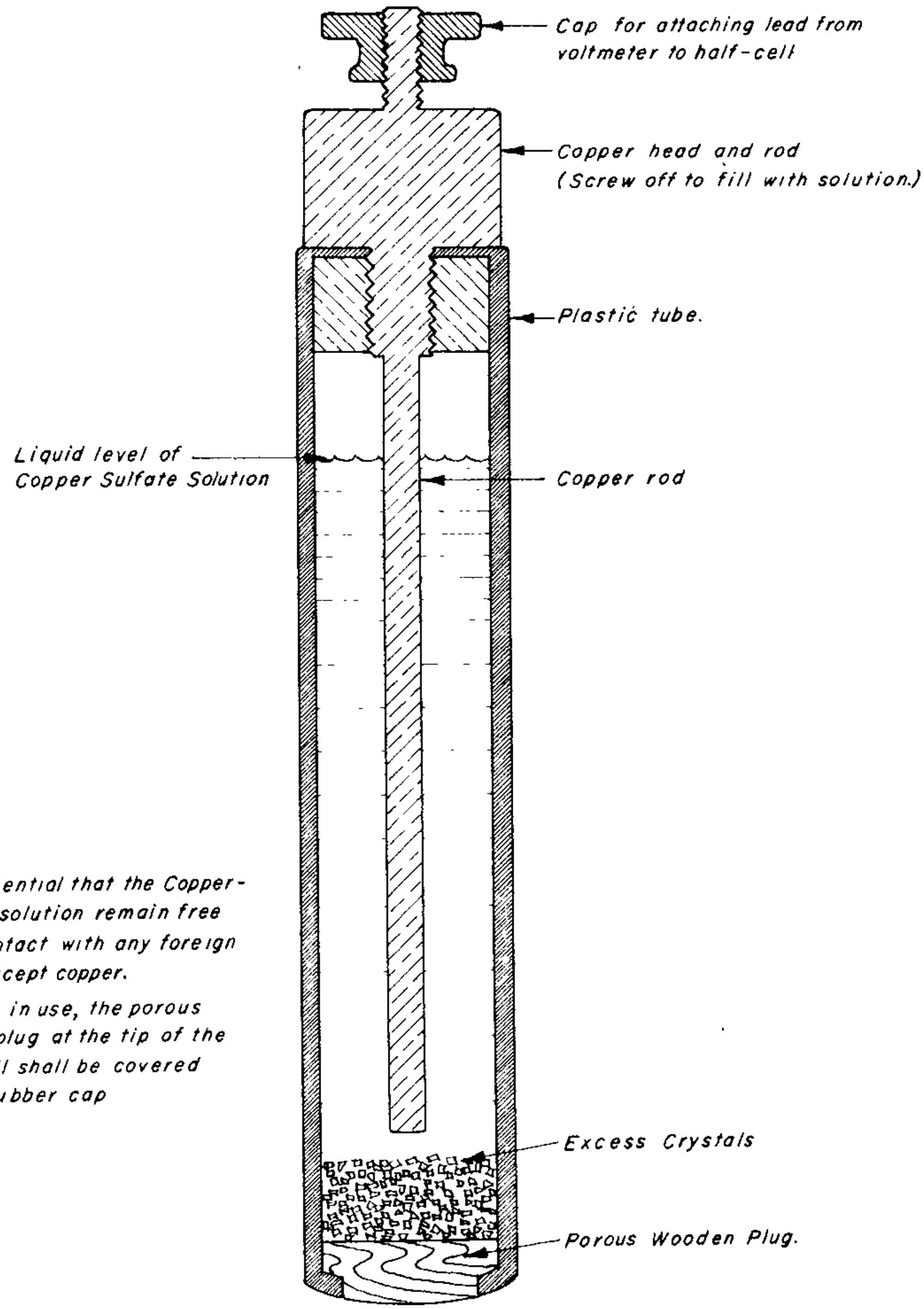
LEAK RECORD

	Date Leak Detected	Location and Remarks
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		

NOTE: Forward monthly copy to Corrosion Engineer,
Materials and Research Department
Sacramento, California

EXHIBIT II

SECTION VIEW OF COPPER SULFATE HALF-CELL

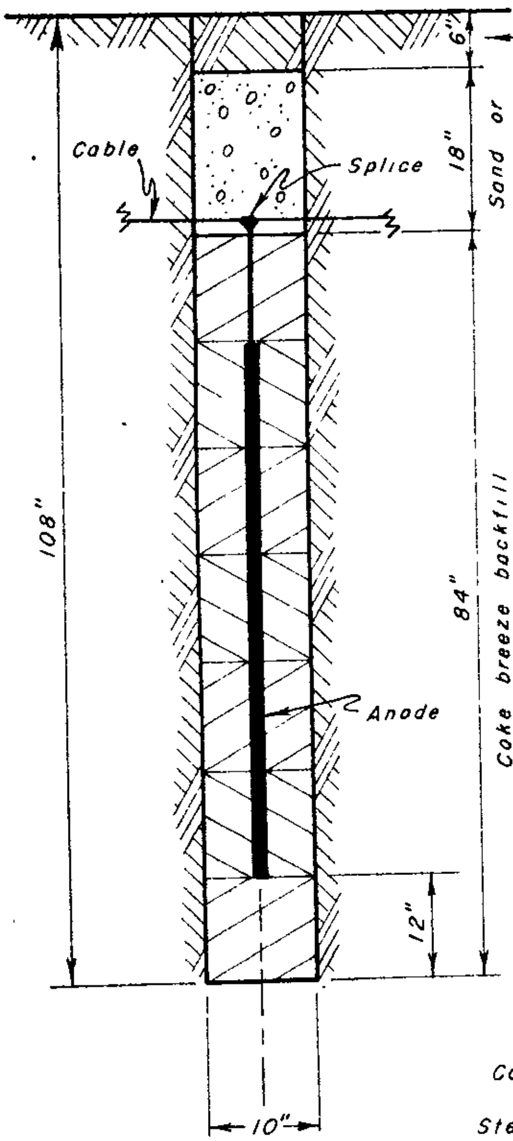


Note.

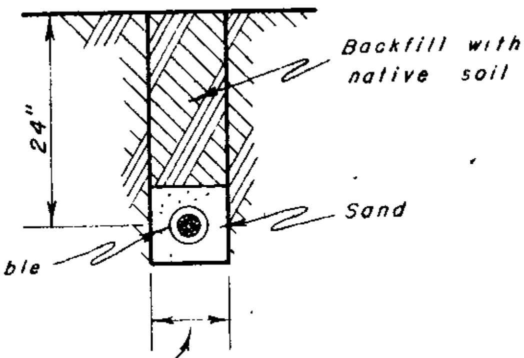
1. *It is essential that the Copper-Sulfate solution remain free from contact with any foreign metal except copper.*
2. *When not in use, the porous wooden plug at the tip of the half-cell shall be covered with a rubber cap*

EXHIBIT III A
INSTALLATION DETAILS
OF
IMPRESSED CURRENT ANODES

ANODE DETAIL

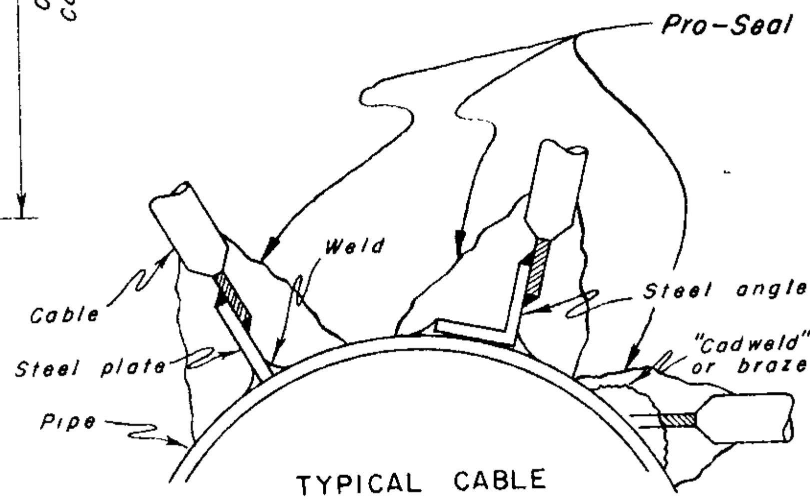


CABLE DETAIL



Cable trench width equals 3" plus O.D. of cable.

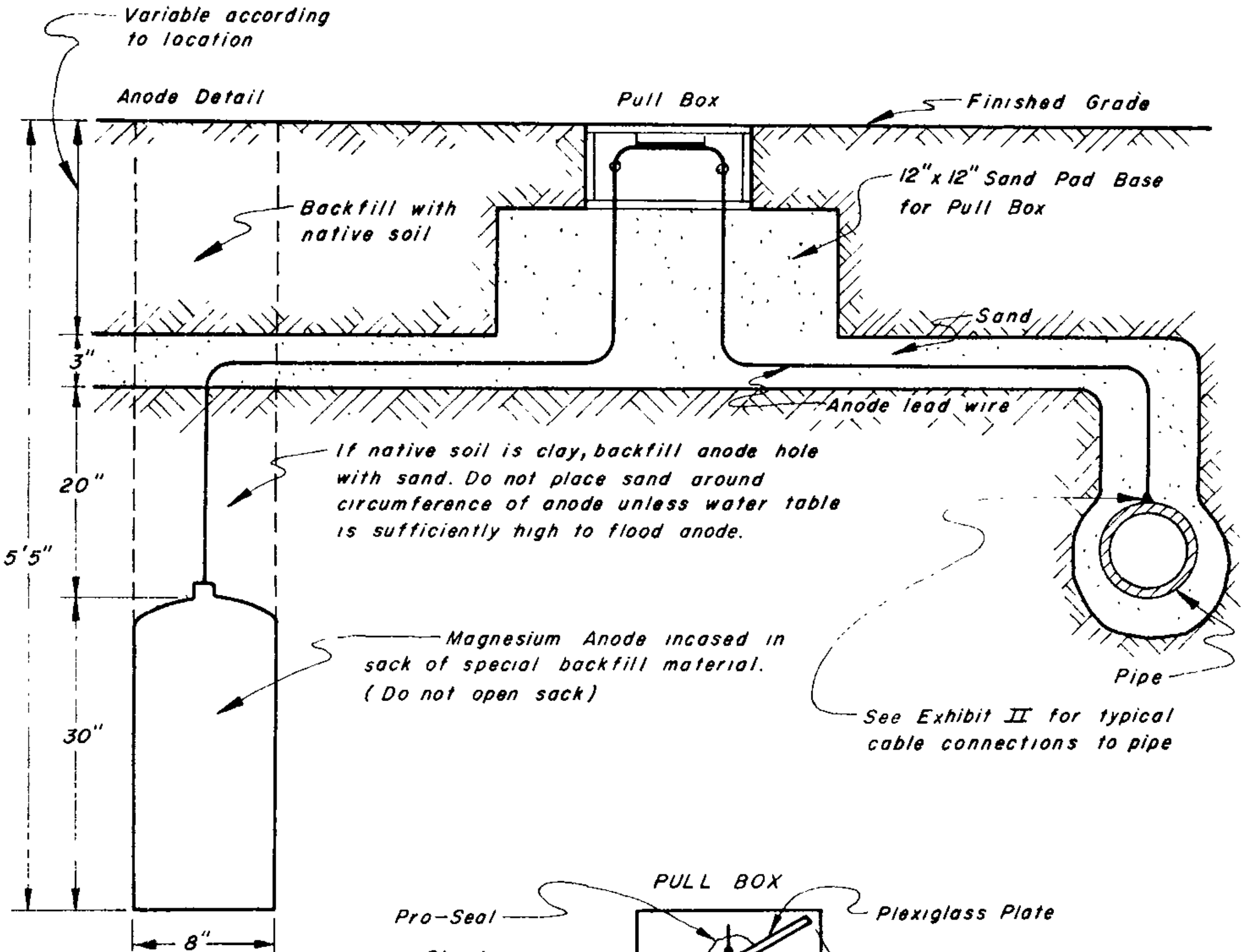
Cable shall have a min. of 1 1/2" sand blanket all around in expansive clay soils. In sandy soils, omit sand blanket and trench width to be minimum of 1" plus O.D of cable.

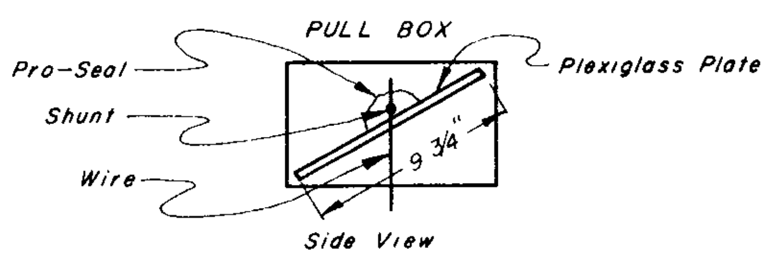


TYPICAL CABLE CONNECTIONS TO PIPE

Minimum dimensions of steel connector to be 3/8" thick and 2" in other directions. Cable to have a min of 1" length brazed or otherwise connected to steel connector or pipe. The steel connector is to be welded all around. Pro-Seal EP-711, or equal, shall be spread a min of 1/4" thick 3" beyond all exposed metals used for connecting the cable to the pipe. When using pipe clamps, the metal surface is to be thoroughly cleaned for the area covered by clamp and then seal clamp and connection with Pro-Seal to minimum of 1/4" thick. A sand blanket shall be placed 6" in all directions from the cable connection prior to backfilling with native soil

EXHIBIT III B
INSTALLATION DETAILS
OF
GALVANIC ANODES



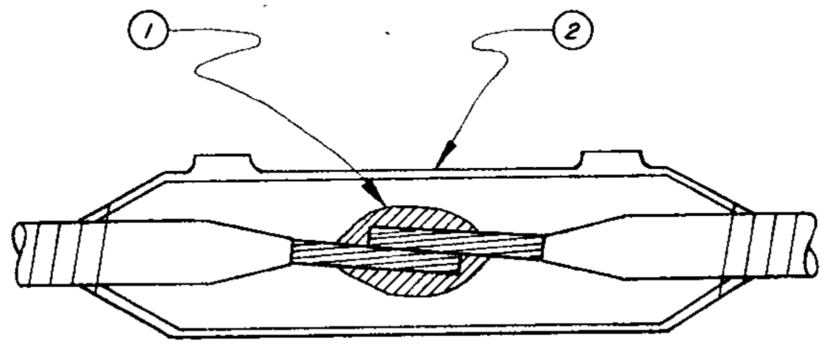


NOTE: Connect shunt to lead wire, solder and capsulate shunt and lead wire to have 1/4" min Pro-Seal all around. Then mount the capsulated shunt on the plexiglass plate (9 3/4"x 6"x 1/4"); attach with Pro-Seal, making sure the metering leads are in a vertical position. Install plexiglass plate in Pull Box as shown.

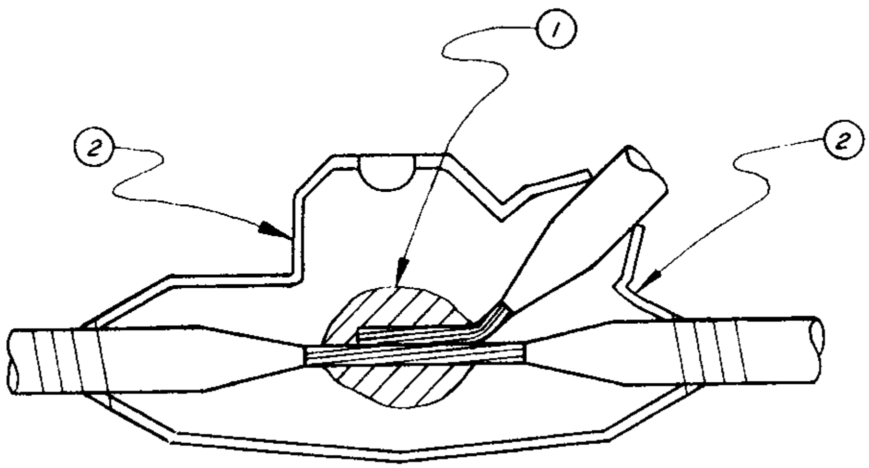
No Scale

EXHIBIT IV

CATHODIC PROTECTION
CABLE SPLICING DETAIL



IN-LINE



WYE

1. *Weld connection by the Cadweld Process.*

2. *Scotchcast splicing Kit utilizing an epoxy type resin.*

NOTE: Cable at the splice shall be free of dirt, grease, or other foreign matter prior to the application of sealing materials.