FIGURE 1

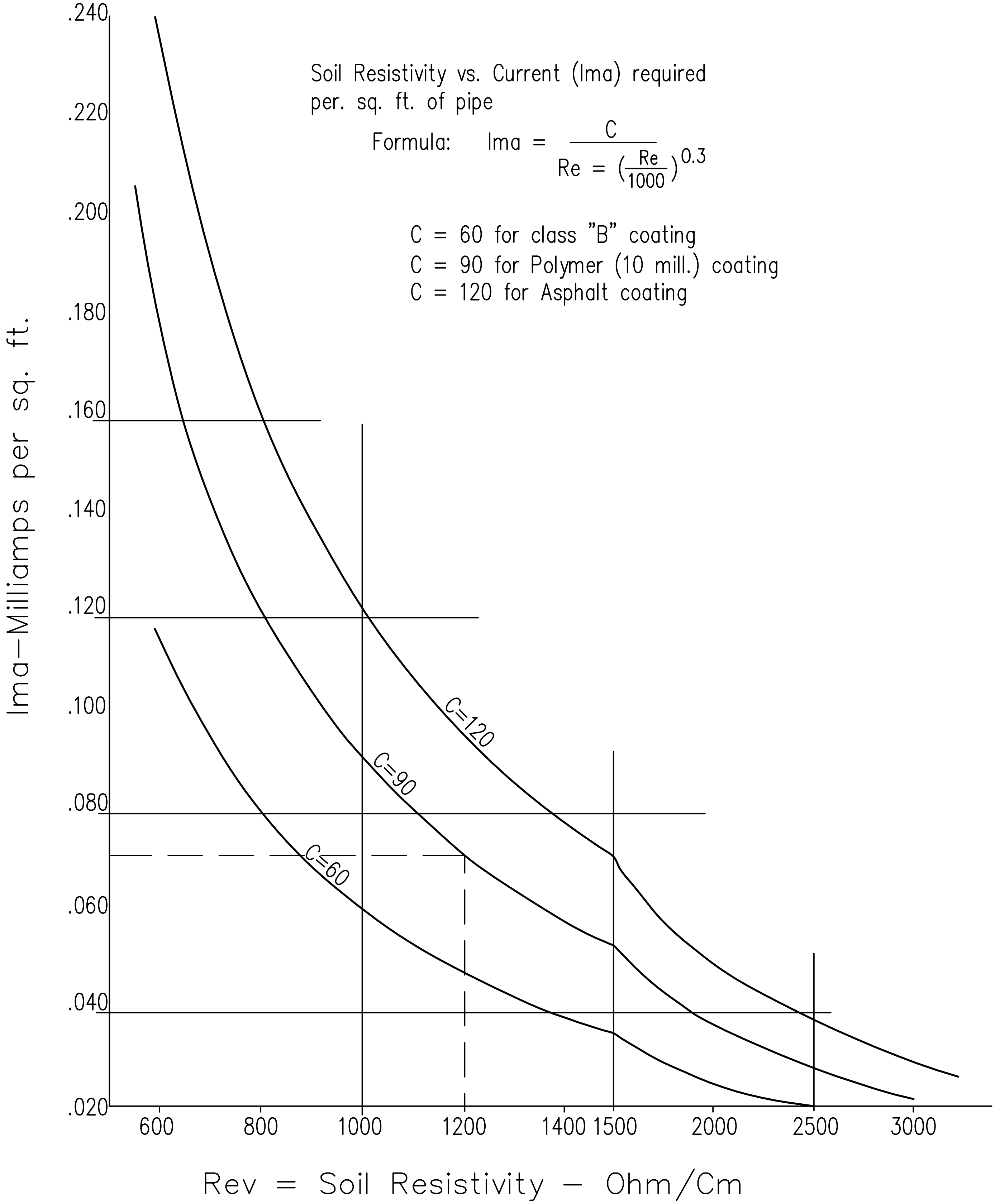

.240
.220
.200
.180
.160
.140
.120
.100
.080
.060
.040
.020
Ima-Milliamps per sq. ft.
Soil Resistivity vs. Current (Ima) required
per. sq. ft. of pipe
Formula: Ima = C / Re = (Re/1000)^0.3
C = 60 for class "B" coating
C = 90 for Polymer (10 mill.) coating
C = 120 for Asphalt coating
C=120
C=90
C=60
600
800
1000
1200
1400
1500
2000
2500
3000
Rev = Soil Resistivity - Ohm/Cm

FIGURE 2

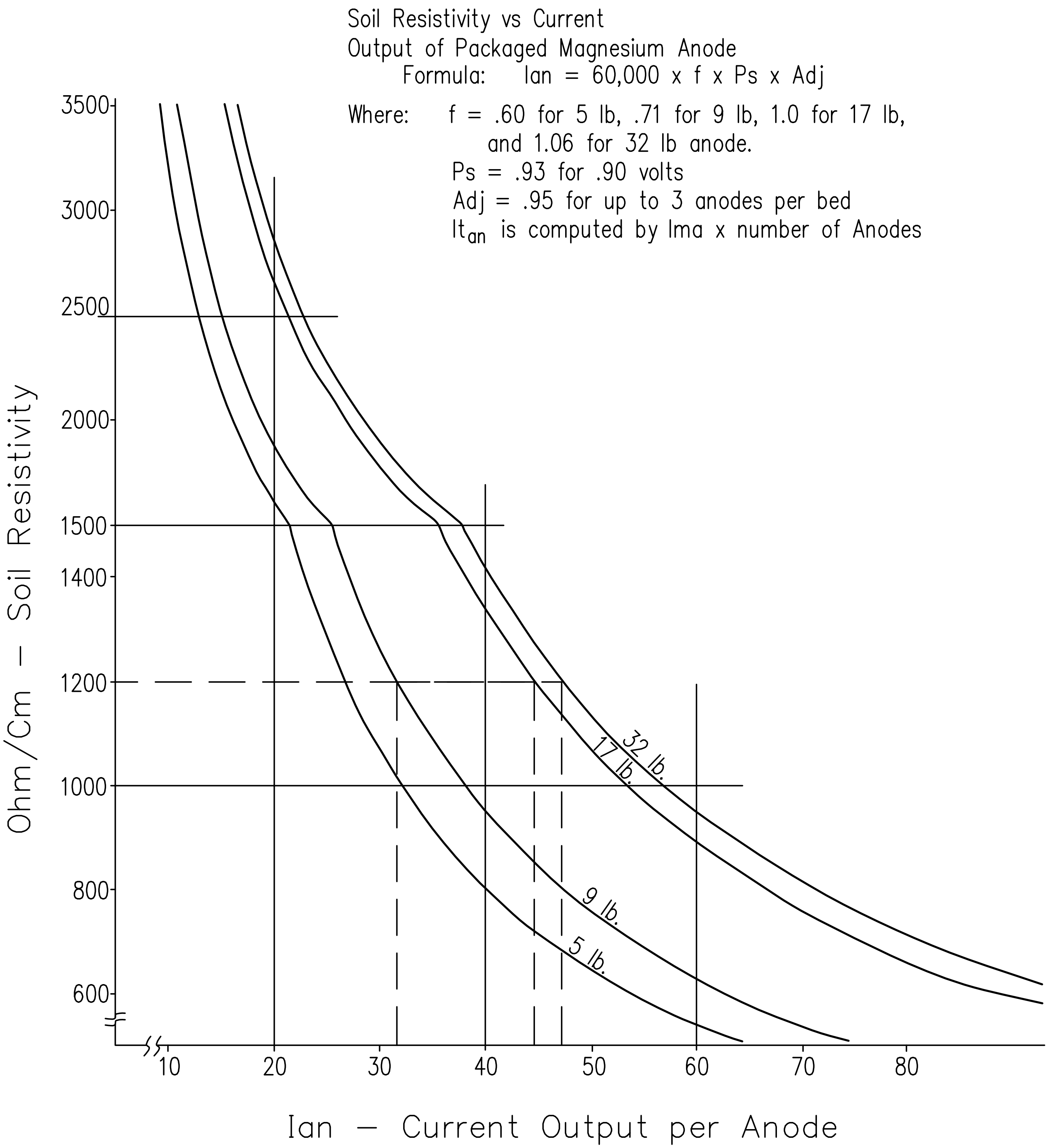
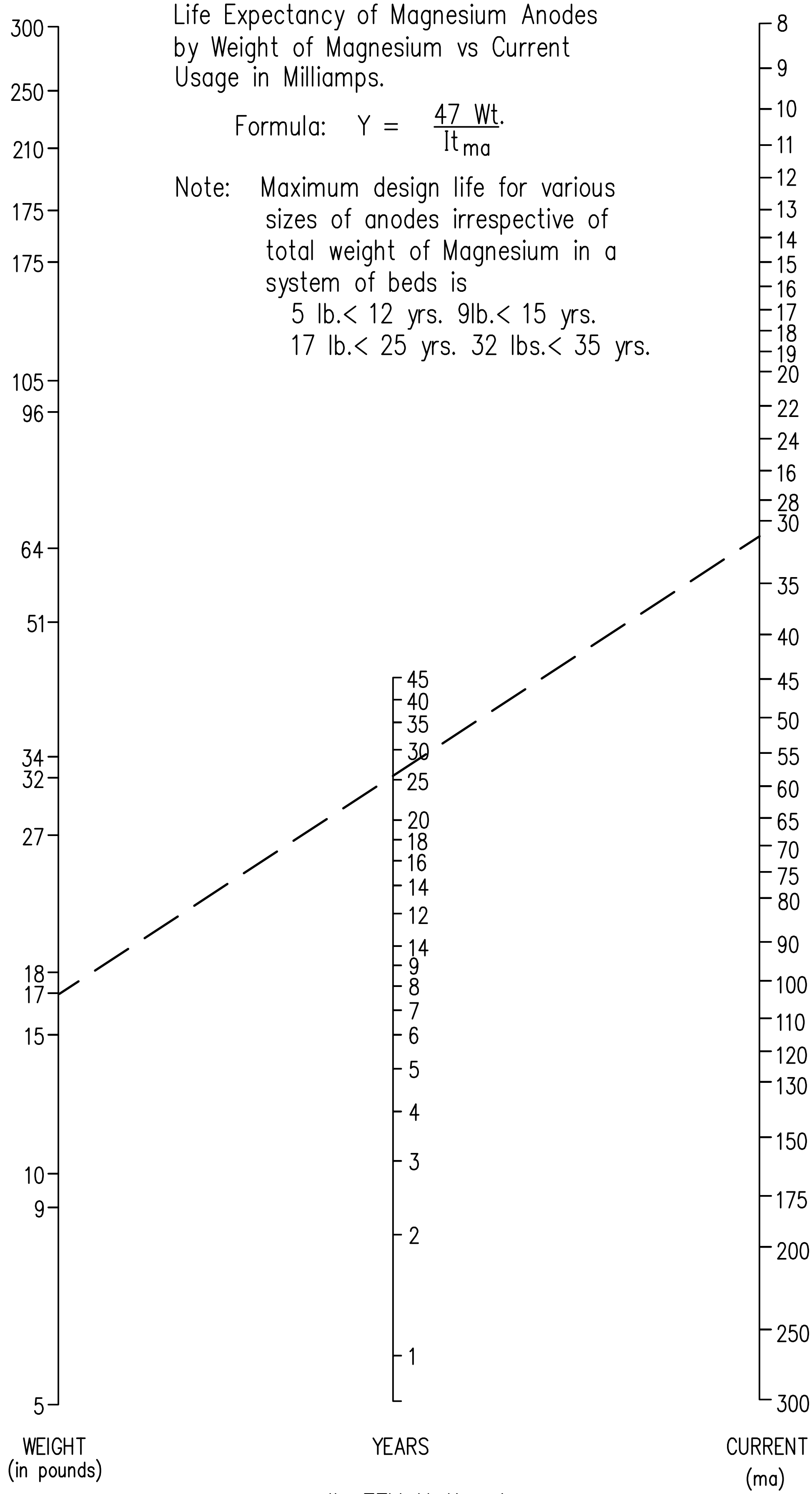

Soil Resistivity vs Current
Output of Packaged Magnesium Anode
Formula: Ian = 60,000 x f x Ps x Adj
Where: f = .60 for 5 lb, .71 for 9 lb, 1.0 for 17 lb, and 1.06 for 32 lb anode.
Ps = .93 for .90 volts
Adj = .95 for up to 3 anodes per bed
It an is computed by Ima x number of Anodes
3500
3000
2500
2000
1500
1400
1200
1000
800
600
10
20
30
40
50
60
70
80
32 lb.
17 lb.
9 lb.
5 lb.
Ohm/Cm – Soil Resistivity
Ian – Current Output per Anode

FIGURE 3

Life Expectancy of Magnesium Anodes by Weight of Magnesium vs Current Usage in Milliamps.

Formula: $Y = \frac{47\ Wt.}{It_{ma}}$

Note: Maximum design life for various sizes of anodes irrespective of total weight of Magnesium in a system of beds is
5 lb.< 12 yrs. 9lb.< 15 yrs.
17 lb.< 25 yrs. 32 lbs.< 35 yrs.

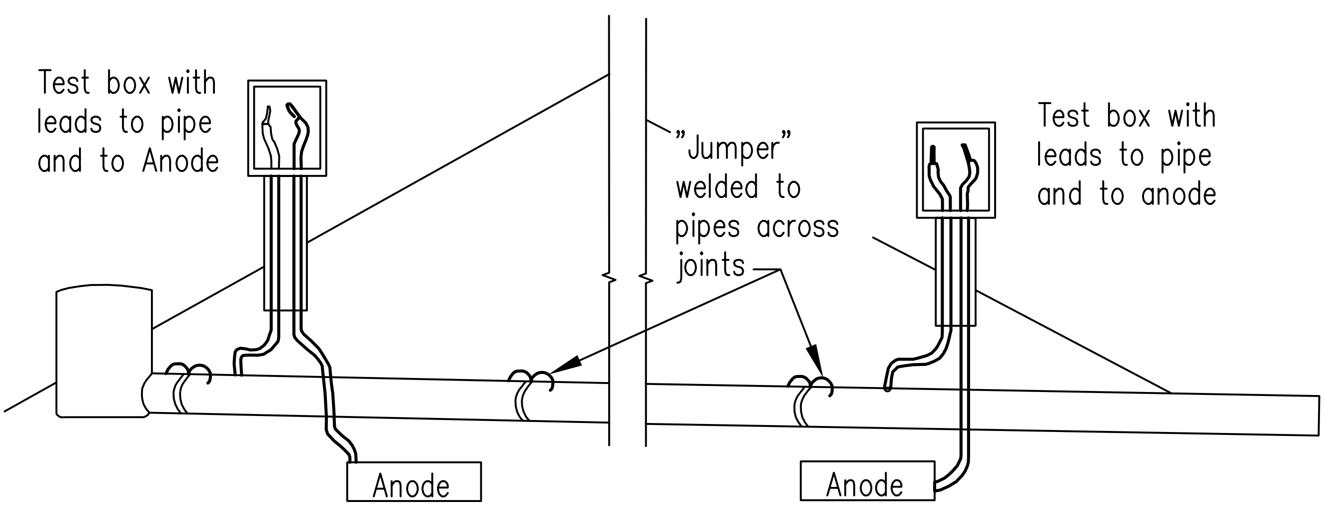


CATHODIC PROTECTION MAINTENANCE TESTS

A number of structures throughout the state have corrugated metal pipe with cathodic protection by magnesium anodes. The purpose of the system is to protect the pipe from rapid deterioration by electrolytic corrosion (rusting out in the wet conditions of a normal dam).

These cathodic protection systems need to be checked periodically (about once each 2 to 4 years) to make sure they are still functioning. Testing of the system is relatively straightforward, but special equipment is necessary to perform the test. Each of the cathodic protection systems has a test box(es) installed to facilitate the checking of the system.

The anodes are a very low voltage–current flow system with a voltage and current flow less than that of a 2–cell flashlight. As the anode corrodes to supply the small current, it is being "sacrificed" to keep the pipe from corroding and, eventually, is used up to the point where the anode, like a battery, ceases to function. Since the anodes are planned to last from 25 to 40 years of productive life, the most likely problem in a system are a broken wire, wire connections, or a weld. A schematic of a system looks like this.

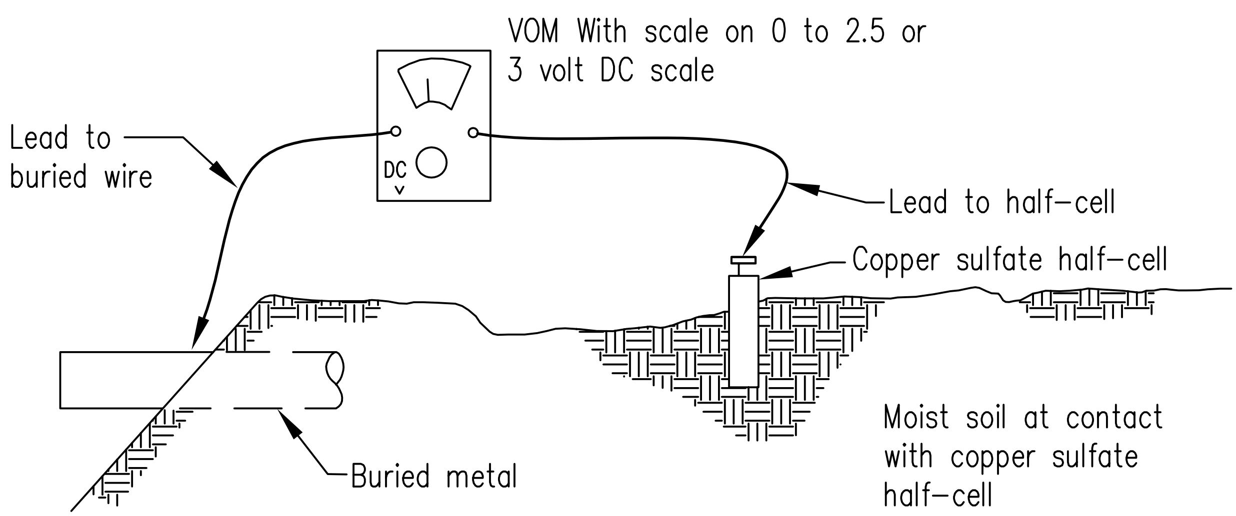


Schematic of a Cathodic Protection Installation

The four tests normally used for checking the system are:

1. Test the pipe for voltage potential by comparing to a copper sulfate half-cell.

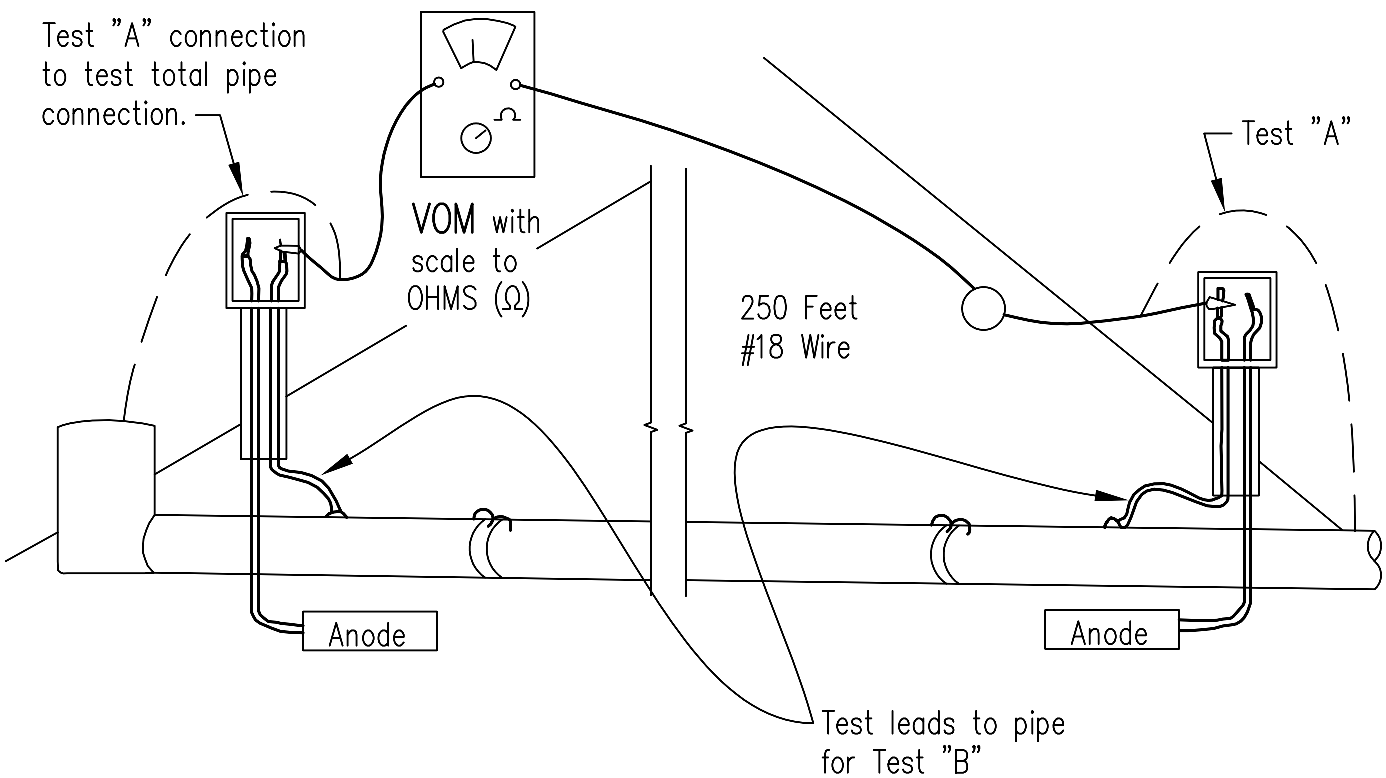
The copper sulfate half-cell is a specialized half of a battery cell which, when placed in contact with the ground and connected through a volt meter to a metal in contact with the ground, will produce a comparative voltage for the metal to soil. The comparative voltage for a corrugated metal (iron) pipe that is protected should be 0.85 volt or higher. Less than 0.80 means the pipe is probably corroding, and the lower the comparative voltage, the more rapidly some areas of the pipe are probably corroding.



Schematic of Using Copper Sulfate Half-Cell

2. Testing continuity of the pipe

The pipe should act like one large wire from riser to the last fully buried joint so that current added from the anodes will follow through and protect the total length of the pipe. Since a weld under a fill on on a small pipe is almost impossible to correct, the pipe is thoroughly checked before backfill is completed. This is done with an ohm meter with a small internal battery to supply the low voltage. The same procedure can be used to check for breaks in a pipe circuit as the pipe ages. See schematic below.

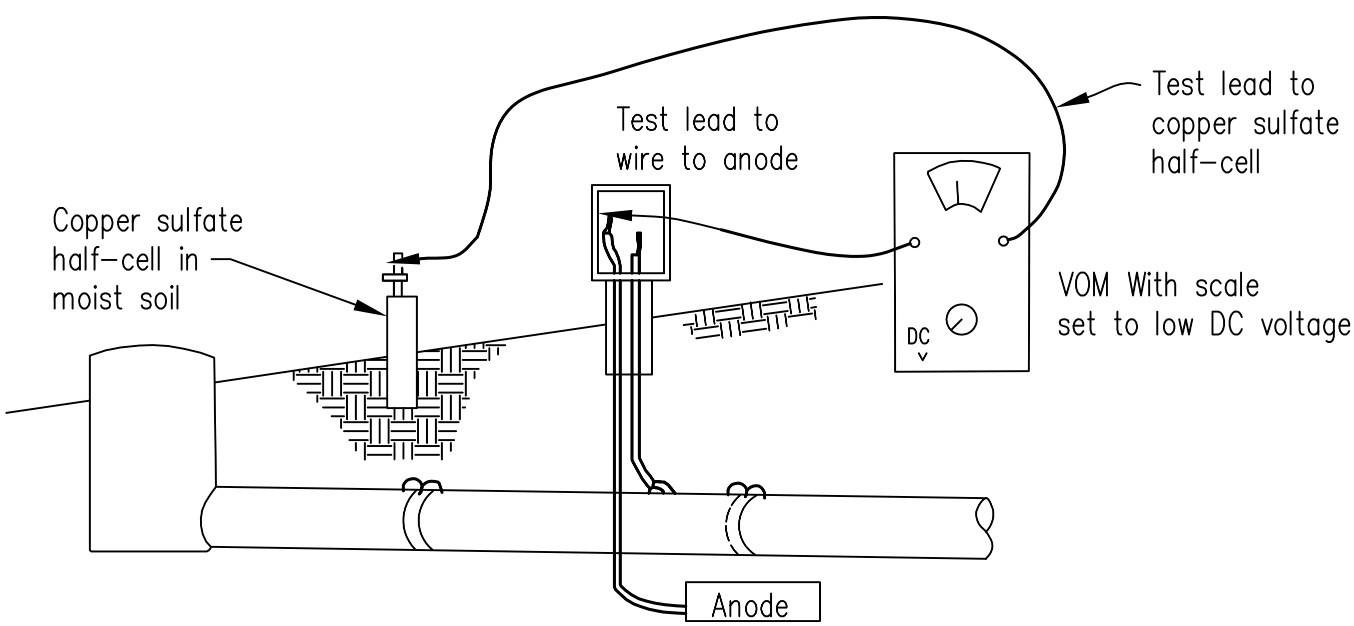


Schematic of Test of Connections to Pipe and Pipe Continuity

Test "A" will show if the pipe is making a continuous circuit. Test "B" will show if either of the wires between the test box and the pipe is broken or has a bad connection to the pipe.

3. The voltage output of the anode.

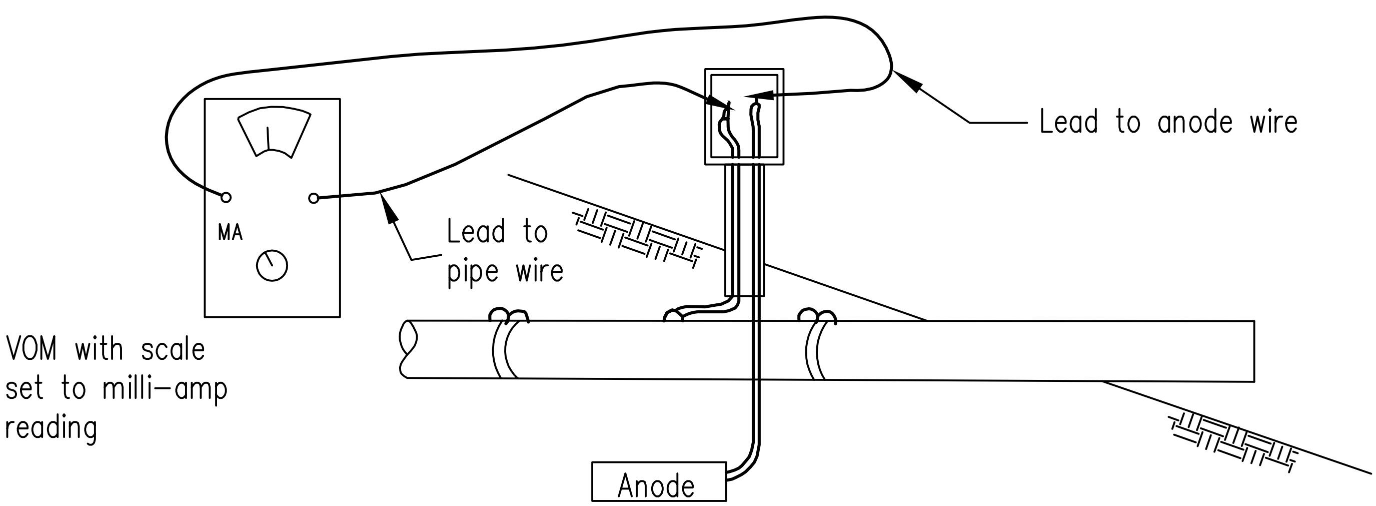
This test is a comparative test using the copper sulfate half-cell the same as Test 1 The normal anode potential voltage will be in the range of 1.4 to 1.6 volts. A 0 to 0.3 voltage reading means the wire or a connection is broken between the test box and the anode. Sometimes this can be corrected by digging to the base of the post, back toward the anode, and checking the wire for breaks, since the break often is at the base of the post due to the post having been knocked over. A schematic of the test is:



Schematic of Voltage Potential of Anode to Copper Sulfate Half-Cell

4. The measuring of the current flow from the anode(s) to the pipe.

This could vary from 5 ms (0.005 amp) to 300+ ma (0.3 amp), depending on pipe area, soils resistivity, and soil moisture. A current flow larger than the design current usually means the pipe is protected to a higher level than needed and a waste of the anode, which will result in a reduced anode life. If the current is more 1.3 times the design needs, a resistance should be added to the circuit. This is done with a length of special high-resistance wire between the connections in the test box.



Schematic of Anode to Pipe Current Flow

The basic equipment needed to perform the maintenance test is as follows:

250' to 300' of rubber–coated #18 wire (best handled on a reel)

1 – Volt ohm–milliamp (VOM) meter

with – DC volt ranges of 0 to 2.5 or 3 volts.

– milliamp ranges of 0 to 500 with 2 lower maximum deflection ranges

– ohm ranges with expanded scale in the 1 to 5± to ohm range

(There are several good models in the $40 to $110 to range.)

1 – Copper sulfate half–cell with porous plug (cost about $25).

The half–cells are available from any supplier of corrosion engineering testing equipment. Some of these are:

Harco Corp., Omaha, NE (402–397–5510)
Agra Engineering Co., Tulsa, OK (618–584–4235)
Century Corrosion Control, Kansas City, MO (816–221–4959)

– Need 2 or 3 extra 4– to 8–ft leads of #18 wire with small alligator clips.

Total cost will be between $100 to $180, depending on the VOM selected.