

O&M Manual

Pipeline Bid Package B1
Southern Diagonal Transmission Main
Project No. 788014
OCA No. 633972

Cathodic Protection Rectifiers

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A. Equipment Data Sheets

Cathodic Protection Rectifier

UNIVERSAL AIR COOLED STANDARD LINE

Models

Rectifier # ASAI 50 – 10 BBCNPQ

P = 4 Coarse and 5 Fine taps

Q = 3.5" meters

= two positive and three negative terminals

1 – Rectifier # ASAI 70 – 25 BBCNPQ

P = 4 Coarse and 5 Fine taps

Q = 3.5" meters

= two positive and three negative terminals

EXCEPTIONS:

1. The cases are made of 11 gauge steel, not 10 gauge.
2. All fuses are replaced with circuit breakers, no fuses are provided.

The Universal Standard Line Cathodic Protection rectifiers are recognized as the leader in quality and workmanship. Many years of field proven service has led to the design of our rectifiers. Conservative ratings, controlled manufacturing techniques, plus many extra features insure long and trouble free operation.

Standard features found in the "Standard Line" Series

- * 11 Gauge hot dipped galvanized Nema3R case.
- * Front & side opening doors.
- * Heavy-duty draw-pull latch.
- * Slide out racks
- * Heavy duty transformer with 15% over design
- * 18 step voltage control taps.
- * Engraved bakelite panel.
- * Quick change heavy duty knobs for changing tap link bars.
- * Minimum 5/16" diameter soldered tap changing studs.
- * Accessible shunt, plainly marked.
- * Heinemann magnetic circuit breaker.
- * Hoyt Model 17-3 Meters.
- * Tri-amp high density selenium.
- * Micro semi avalanche silicon diodes protected by surge suppressors and current limiting fuses.
- * All electrical connections double nutted or soldered.
- * Multi-strand high temperature extra flexible wire.
- * Terminal block for AC input wires.
- * Primary tap change panel for dual input voltages.
- * Dead front panel supplied on all units over 60 volts D.C.



B. System and Component Description

CATHODIC PROTECTION OF PIPELINES

SYSTEM DESCRIPTION

Cathodic protection is applied to underground and submerged pipelines to stop corrosion at external areas of bare steel exposed to the corrosive surrounding soil or water. The protective coating is the first line of defense against corrosion but all coatings are damaged to some extent at installation and will deteriorate with time. Properly applied cathodic protection, in conjunction with the protective coating, will provide 100 percent corrosion protection through the service life of the pipeline.

Corrosion occurs as a result of voltage differences at the exposed metal surface. The areas of different potential are referred to as cathodes (positive) or anodes (negative). These voltage or potential differences are a result of differences in the soil or water caused by variations in chemistry, water content, presence of bacteria, temperature, resistivity etc. Differences in the metal itself such as stress levels, weld seams, chemistry, grain composition, temperature etc., will result in potential differences.

Potential differences cause corrosion currents to flow, which dissolve the metal at the anodic areas.

If these potential differences can be removed, corrosion will not occur.



Cathodic protection current when applied from an external source to a buried or submerged metal surface will cause the potential of the cathodic areas to move (polarize) in the negative direction. Providing sufficient cathodic protection current is applied, all the cathodic areas will be polarized in the negative direction so that all areas on the metal surface are at the same potential as the most negative anodic area. At this point ALL potential differences are removed from the surface and so the corrosion currents are eliminated completely. This is cathodic protection.

It has been empirically determined that the most negative naturally occurring anodic area is not as negative as -0.850 volt referenced to Cu/CuSO_4 electrode. Thus the adopted standard for full cathodic protection is that the protected surface be polarized to a potential of -0.850 volt or more negative. Please refer to Section 6 of NACE SP0169 for details of the allowable criteria for full cathodic protection. Test stations provide locations where potential measurements can be made to evaluate the level of cathodic protection on a buried pipeline.

To apply and monitor cathodic protection current to a pipeline using impressed current systems, several components are required.

Electrical Continuity – the pipeline must be electrically continuous over the full length to be protected. For welded pipelines the weld provides the continuity at joints. For concrete, ductile iron and mechanically jointed pipelines welded clips or cables attached by Cadweld are required to complete electrical continuity.

Electrical Isolation – The cathodic protection system is designed to protect the external surfaces of the pipeline. Any other buried or submerged metallic structure connected to the pipeline will drain current from the system. In an extreme case this unexpected additional drain on the system will leave the pipeline unprotected through lack of capacity.

To avoid losing CP current, the pipeline is electrically isolated from all other metallic structures. This involves the installation of isolation flange kits or joints at the extremities of the protected pipe. In addition isolators and end seals are installed in steel casings.

Test Stations – electrical connections to the pipeline will allow potential measurements to be made to evaluate the level of cathodic protection. Test stations provide insulated cable connections to the protected pipeline, foreign pipelines, steel casings or other underground structures of interest. Please refer to the drawings for details.

Impressed Current Anodes – Cast Iron anodes are used as the external source of cathodic protection current. These anodes are buried at depth and are capable of discharging high currents for an extended period of time. The anodes are installed at depth in a drilled hole. The anodes are lowered to the correct depths and surrounded by coke breeze. The coke breeze acts as an extension of the anode length and diameter thus reducing the resistance to earth thus reducing power costs, provides good earth contact and extends anode life. The anodes are connected to individual shunts through unspliced insulated cables. Please refer to the drawings for details.

Anode Shunts - the anode shunt panel marshals the individual anode cables and provides a single cable connection to the positive of the transformer rectifier. Current measuring shunts allow the performance of the individual anodes to be monitored. Please refer to drawings for details.

The transformer rectifier converts AC power to DC cathodic protection current. The high voltage AC is first transformed to a lower voltage AC (this voltage is selected by manual taps on the transformer secondary) and then rectified to DC cathodic protection current via a diode bridge. The negative of the rectifier is connected directly to the protected pipeline by cable connected by Cadweld.



Cabinet – this enclosure houses the transformer rectifier.

The operation of the cathodic protection system requires that current flows from the transformer rectifier positive through the anode shunts to the individual anodes. The anodes discharge current, via the coke breeze backfill to earth, a process, which causes corrosion of the anodes. The current will travel through the earth for unlimited distances, since the earth is effectively a zero resistance conductor.

The pipeline will collect current from the soil at areas of pipe exposed through pinholes or holidays in the protective coating. The passage of sufficient CP current across the soil / steel interface will provide full cathodic protection, eliminating corrosion.

The current enters the pipe steel wall and returns to the rectifier via the pipe wall, joint bonding cables and the negative return cable.

C. Maintenance Schedule

RECTIFIER - MAINTENANCE SCHEDULE

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

Proper maintenance is essential for the operation of all cathodic protection systems.

The rectifier should be inspected on a monthly basis and records maintained of the DC voltage output and DC current output readings.

The complete or partial failure of a cathodic protection system is not usually accompanied by any visible signs. If a power system fails, the machinery using the electrical energy will cease to operate. This will immediately stimulate investigation of the problem. Such is not the case, however, with cathodic protection systems. Very often the only means of detection is noting the change in structure-to-soil potential through the use of instruments. If there is a failure on a cathodic protection system the relatively slow process of corrosion resumes and continues until a leak occurs. At this point, great damage has been done and large expenses will be encountered to make the necessary repairs. Economic and safety considerations require close supervision and maintenance of all cathodic protection systems.

In addition to the change (or increase) in structure-to-soil potential, several other indications of failure may be detected. With impressed current systems, changes in rectifier output may indicate problems. If the system is totally inoperative, a drop in power consumption may be indicated on the monthly power bill.

D. Installation Instructions

RECTIFIER – Installation Instructions

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

I. SITE SELECTION CONSIDERATIONS:

The following should be considered for site selection:

1. The proximity of the cathodic protection system.
2. The proximity of the available AC power source.
3. Avoid congested areas of electrical or mechanical heat producing equipment.
4. Avoid areas of direct sunlight and lack of proper air circulation.
5. Do not install the rectifier in a confined area.
6. Avoid areas that will promote human contact.
7. Site selection should allow full accessibility to the rectifier and allow doors to open fully

II. MOUNTING:

1. The rectifier must be mounted securely with minimum 5/16" diameter lag screws, anchor bolts, or machine bolts to a substantial, permanent, wall, pole or rack assembly.
2. The rectifier should be mounted level and straight to provide proper door operation
3. When mounting the rectifier to a hollow wall or structure, check for concealed wiring, water lines, etc., before drilling any mounting holes.

III. WIRING:

1. All wiring must comply with the National Electrical Codes and all existing local codes.
2. Local electrical codes many require all wiring to be installed in approved conduit.
3. AC power must be supplied from a disconnect circuit breaker or branch circuit protection circuit breaker.
4. Wire sizes must comply with the National Electrical Code. 8. The POSITIVE terminal must be connected to the anodes.
5. The rectifier cabinet must be grounded by the terminal provided at the AC input power terminal block marked "G" or "GROUND".
6. AC input power must be installed into the appropriate terminals marked "L" or "LINE" and "N" or "NEUTRAL".
7. The NEGATIVE output terminal must be wired to the STRUCTURE to be protected.
8. The POSITIVE terminal must be connected to the anodes.

E. Operation Procedures

RECTIFIER – Operation Procedures

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

Operating personnel should observe the following before attempting to operate or adjust the rectifier:

1. Do not tamper with AC power supply terminals of AC circuit within the rectifier unless the AC power, external to the unit, is turned "OFF". Contact with this high voltage can produce severe or fatal shock.
2. Rectifiers with DC ratings above 50 volts DC have high voltage on the adjustment taps, AC to stack terminals, and can not be handled unless rectifier circuit breaker is turned "OFF".
3. Do not exceed AC or DC ratings of the rectifier. Operating the rectifier at higher than nameplate ratings will result in eventual failure of the rectifier.
4. If overload protection trips repeatedly, investigate and eliminate cause before attempting further operation of rectifier.
5. If rectifier components overheat, or there is any evidence of electrical failure, turn rectifier "OFF", immediately. Do not attempt to operate rectifier until proper inspection and repairs have been completed.
6. The positive DC output terminals should always be connected to the anodes. NEVER connect this positive DC terminal to the structure to be protected, as irreparable damage will occur to the structure.
7. Oil immersed rectifiers must have the oil level maintained at the specified level for proper cooling of components and also to meet rigid requirements for Class 1, Group D hazardous areas.
8. For three phase units, all similar (coarse or fine) voltage tap settings MUST be on the same "step" in all phases before AC power is turned "ON". Operating the rectifier with either the coarse or fine taps on different settings will destroy the transformer.
9. Return instruction manual and wiring diagrams to pocket provided on the inside of door. Do not place in bottom of rectifier and allow ventilation to be restricted.

ROUTINE CHECKS PRIOR TO OPERATION:

Your Universal Rectifier was fully inspected, carefully tested and was in top operating condition at the time of shipment. Instances where damage has resulted in shipping, handling, storage or installation are rare but possible. As a result, the following routine checks of your Universal Rectifier, as well as the external AC and DC circuits are recommended:

1. **VISUAL INSPECTION.** Inspect unit for possible damage that may have resulted in shipping, handling, or installation. If damage exists, do not attempt operation of rectifier until repairs have been completed.
2. **AC POWER SUPPLY.** Check phase and voltage of AC power supply. These should correspond to AC ratings of the unit. Where rectifiers have dual voltage ratings (110/220 or 220/440) care should be taken to make AC connections for voltage employed. Notice tag attached to panel indicates AC voltage wiring of the unit. Wiring diagram indicates changes to be made for other input AC voltages.

3. **DC CIRCUITS.** Zero the DC meters. External DC load should be in proper operating condition. Connect ground bed (anodes) to positive (+) DC output terminal. Connect structure to be protected to negative (-) DC output terminal.
4. **CONNECTIONS.** Make sure all connections to and in your Universal Rectifier are tight. Where Universal voltage tap changer is used, voltage tap adjusting knobs need only be hand tight.

TO PLACE YOUR UNIVERSAL RECTIFIER IN OPERATION:

When in operation, the actual DC voltage and current output of the Universal Rectifier are indicated by the voltmeter and ammeter on the instrument panel of the rectifier. Care should be taken that these meter readings do not exceed either the DC voltage or DC current ratings of the unit. If ratings are exceeded, turn AC power "OFF" immediately. During the voltage tap changing operation described below, the AC power should be turned "OFF" at the circuit breaker or safety switch.

Observe the above and proceed as follows:

1. Set all voltage tap controls on lowest setting.
2. Turn external AC power supply "ON".
3. Close circuit breaker or safety switch of rectifier ("ON" position).
4. Check DC ammeter and voltage readings on instrument panel.

TO ADJUST DC VOLTAGE AND CURRENT:

The following steps should be followed in sequence observing precautions in steps I, II and III until desired DC current and/or voltage is attained.

1. With coarse control at lowest setting, increase fine control setting in progressive steps throughout its full range and observe DC output voltmeter and ammeter.
2. Before Increasing coarse control setting, return fine control setting to lowest position.
3. Change coarse control setting to next higher position.
4. Repeat steps 1, 2, and 3.
5. Proceed in this manner until current output is obtained.

MAINTAINING DESIRED CURRENT AND VOLTAGE:

The rectifier unit will respond to electrical changes in the system external to the unit, such as pronounced fluctuation of AC line voltage or changes in ground bed resistance. Such changes can alter the operating DC voltage and/ or current output of the rectifier. Periodic inspections should be made to assure desired operation and prevent any overloading. Voltage adjustments should be made as required. A permanent record of the current and voltage readings should be maintained. Any pronounced change that is not attributable to voltage adjustment should be investigated.

F. Maintenance Instructions

RECTIFIER – Maintenance Instructions

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

The following procedures should be followed during the yearly detailed survey of rectifier type systems:

- Examine for physical damage from: vandalism, winds lightning, exposure or overheating.
- Measure and record DC voltage, DC amperage and tap setting on rectifier maintenance sheet. If there are significant changes in output when compared with records of previous visits, further investigation is warranted.
- Turn the rectifier off. Feel the stacks for uneven heating. If all the plates are not at the same temperature, employ the trouble shooting procedures described in the trouble shooting guide of this manual.
- While rectifier is still off, check the bolted electrical connections for heat and tightness.

Once the rectifier unit has been inspected and measured, then proceed with a potential survey.

G. Troubleshooting Guide

RECTIFIER - Trouble Shooting Guide

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

A wiring diagram for use by experienced personnel is provided. Only experienced electrical personnel should attempt location and repair of electrical difficulties, should they occur. Some symptoms of elementary trouble and the possible remedy are as follows:

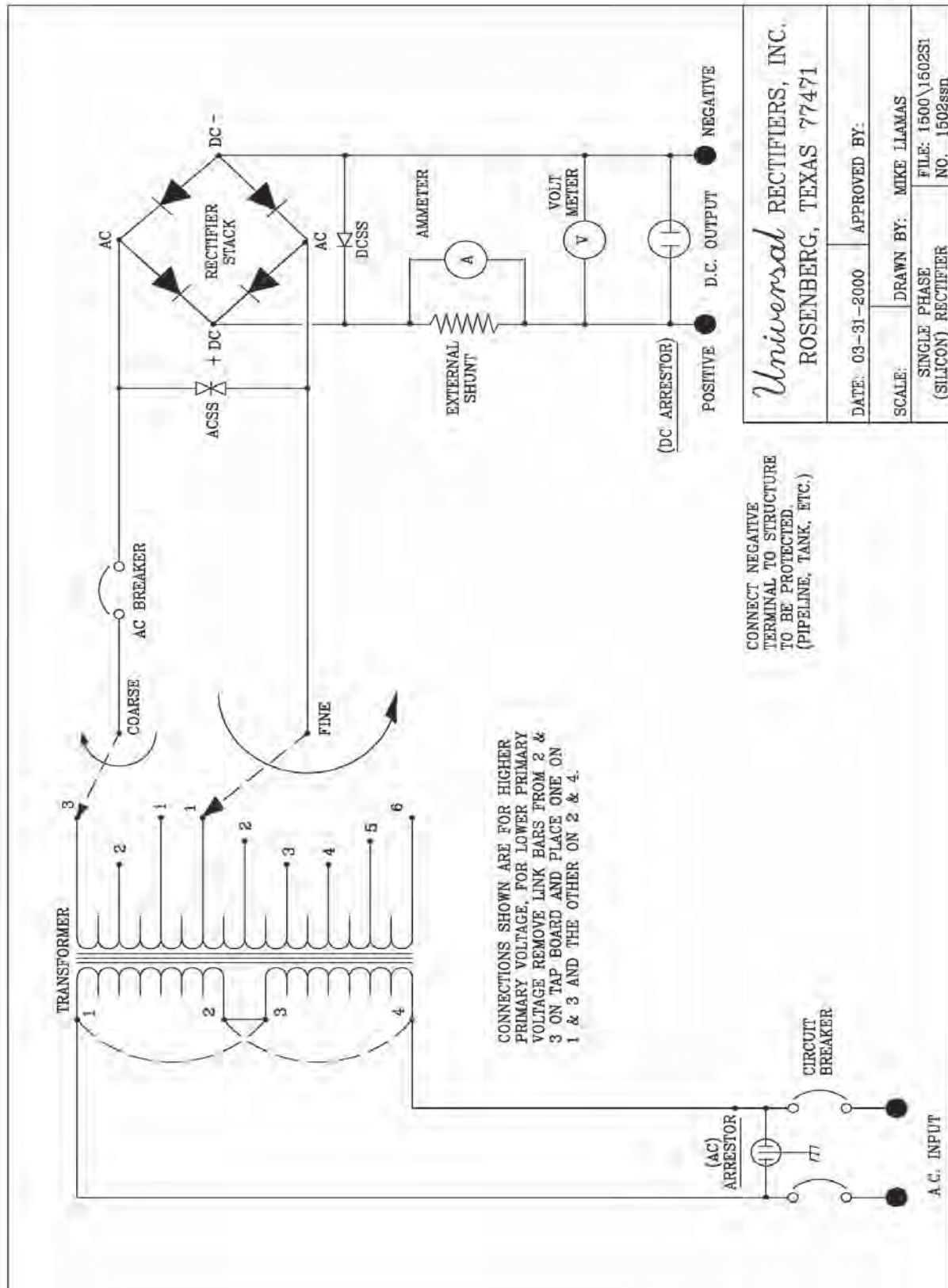
1. NO DC CURRENT OR DC VOLTAGE OUTPUT.
CHECK: AC overload protection for blown fuses or tripped circuit breaker. Check AC power supply.
2. DC VOLTAGE BUT NO DC CURRENT READING.
CHECK: DC ammeter. Check DC, connections and external DC circuit for electrical continuity.
3. DC CURRENT READING BUT NO DC VOLTAGE READING.
CHECK: Check DC Voltmeter.
4. MAXIMUM RATED DC VOLTAGE CANNOT BE ATTAINED.
CHECK: Check AC line voltage. Check voltage adjustment settings for maximum. Check accuracy of DC Voltmeter.
5. MAXIMUM RATED DC CURRENT CANNOT BE OBTAINED AT MAXIMUM DC VOLTAGE.
CHECK: Check load resistance of external DC circuit.

H. Drawings and Spare Parts

RECTIFIER – Drawings and Spare Parts

WARNING! This equipment poses an electrical shock hazard and the following should only be attempted by qualified personnel.

WIRING DIAGRAM



<i>Universal RECTIFIERS, INC.</i> ROSENBERG, TEXAS 77471		DATE: 03-31-2000	APPROVED BY:
		SCALE:	DRAWN BY: MIKE LLAMAS
		FILE: 1500\1502SI	
		(SILICON) RECTIFIER	NO. 1502ssn

**Parts List for rectifier Model #ASAI 50 – 10 BBCNPQ,
Serial No. 110479**

Qty Description

- 1 – AC primary Breaker Heineman # CE-2, 5 amp
- 1 – Transformer 115/230VAC, 1 Phase, 50VDC, 10ADC, 4 Coarse and
5 fine tap adjustments, Universal # 61037B-C
- 1 – Voltmeter Hoyt #17/3, 0 – 50Volts,
- 1 – Ammeter Hoyt # 17/3, 0 – 10 Amps,
- 1 – Shunt Holloway Type SW, 50 Mv – 10 amp
- 1 – Silicon modular stack assembly # 1A5-MB12A35V60
- 1 – AC surge suppressor B40K150
- 1 – DC surge suppressor B40K150
- 1 – AC secondary breaker, MU-1, 15 amp
- 1 – AC terminal block Marathon # 1102
- 1 – AC lightning arrestor # ASZH650C201
- 1 – DC lightning arrestor # AS1B1
- 1 – Type A case, powder coated white steel,

**Parts List for rectifier Model #ASAI 70 – 25 BBCNPQ,
Serial No. 110480**

Qty Description

- 1 – AC primary Breaker Heineman # CE-2, 10 amp
- 1 – Transformer 115/230VAC, 1 Phase, 70VDC, 25ADC, 4 Coarse and
5 fine tap adjustments, Universal # 61153B-C
- 1 – Voltmeter Hoyt #17/3, 0 – 80Volts, redlined at 70 Volts
- 1 – Ammeter Hoyt # 17/3, 0 – 25 Amps,
- 1 – Shunt Holloway Type SW, 50 Mv – 10 amp
- 1 – Silicon diode stack assembly # K34120B1 – N1
- 1 – AC surge suppressor B40K150
- 1 – DC surge suppressor B40K150
- 1 – AC secondary breaker, CA-1, 30 amp
- 1 – AC terminal block Marathon # 1102

I. Technical Data

TECHNICAL DATA

Monitoring Procedures

For the purpose of this Operating and Maintenance Manual, monitoring refers to routine inspection on a bi-monthly basis by company personnel. Maintenance is the more detailed testing and adjustment of the system which should be performed by a qualified Corrosion Engineer.

Monitoring

The following procedures should be followed during bi-monthly monitoring of impressed current cathodic protection systems.

- Read the voltage and current output of the rectifier unit and complete the rectifier maintenance sheet.
- Read the structure-to-soil potential at all test stations and record in an operating log.

If the readings obtained are acceptable, then no further field work is required. If the readings are not acceptable, then the trouble shooting procedures of this manual should be followed.

PIPE TO SOIL POTENTIAL TEST PROCEDURE

Structure-to-soil potential measurements should be obtained at all test stations using the following procedure:

The equipment required to perform the test consists of the following:

- High Impedance Voltmeter
- Copper/Copper Sulfate Portable Reference Electrode
- Test Leads

The test procedure is as follows:

- connect the negative lead of the voltmeter to the pipe test cable
- connect the positive lead of the voltmeter to the copper / copper sulphate reference cell
- use the 2 volt scale
- record the reading noting that a positive reading is actually a negative potential

Pipe to Soil potentials should be measured under three separate sets of conditions.

- Prior to any CP current being applied the native pipe to soil potentials should be measured. These values which are the voltage difference between the pipe and a copper/copper sulphate reference cell are to be recorded on the data sheets following.
- The systems should then be energized and the current output adjusted to provide sufficient current to completely protect the pipeline. After the required period of polarization the following potentials should be measured and recorded.
 - ON Potential - After polarization with the current applied
 - OFF Potential - After polarization with the current interrupted

The structure-to-soil potentials should comply with the NACE International criterion for cathodic protection as written in NACE Standard SP 0169 (latest revision).

Determination of the level of protection should be made by qualified personnel.

J. Other Components

OTHER COMPONENTS

The rectifiers are part of a total impressed current cathodic protection system consisting of the following:

Rectifier & Anode Ground Bed Materials GB(20) & GB(5)
Universal air cooled Transformer rectifier ASAI 50 – 10 BBCNPQ - 50 volt 10 ampere DC output, 480 VAC single phase (delta no neutral) 20 steps bridge silicon stack, surge protection on input and output, metal oxide varistors, fuse in transformer secondary, NEMA 3R enclosure to be steel, shop coated baked enamel finish, two positive and three negative terminals #8 AWG, separate volt and ammeter, to be supplied with one complete set of fuses and manufacturers recommended spare parts, manual and full factory test report.
Universal air cooled Transformer rectifier ASAI 70 – 25 BBCNPQ - 70 volt 25 ampere DC output, 480 VAC single phase (delta no neutral) 20 steps bridge silicon stack, surge protection on input and output, metal oxide varistors, fuse in transformer secondary, NEMA 3R enclosure to be steel, shop coated baked enamel finish, two positive and three negative terminals #8 AWG, separate volt and ammeter, to be supplied with one complete set of fuses and manufacturers recommended spare parts, manual and full factory test report.
#8 AWG HMWPE black
High silicon iron chromium tubular anodes, ANOTEC 60" x 2.2" weight 37 lb center connected to 5' #8 Fluorinated Polymer insulated cable packaged in 8" x 72" can with metallurgical grade coke
Burndy split bolt connector KS-20
Scotchcast 82-B1 epoxy kits
#8 AWG HMWPE RED positive anode header cable

K. Warranties, Bonds, and Service Contracts

LIMITED WARRANTY

This equipment manufactured and designed by Universal Rectifiers, Inc. is warranted against defects in design, workmanship or materials, unless otherwise specified, for one year from the date of installation. The obligation of Universal Rectifiers, Inc. is limited to the adjustment, repair or replacement at its factory of the equipment, or part thereof which shall be found defective upon examination after being returned with transportation charges prepaid. Universal Rectifiers, Inc. warrants this product and its operation only. There is no other warranty or liability implied or expressed for the use or mis-use of this equipment.