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1995 Annual Cathodic Protection Survey Report for the Hanford 200 Area

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1.0 INTRODUCTION

Cathodic protection (CP), as a measure of providing corrosion protection to buried piping, has existed at Hanford since the 1940's. In 1980, the original CP systems were evaluated and found out-dated, not operating properly, and in some cases, not operating at all. The CP systems were shut down and replaced with an updated design. The replacement systems were installed beginning in 1985 in a piece-meal fashion. Installation of new CP systems continue today, with most designs protecting new or upgraded transfer lines.

Since installation, the new CP systems had received little attention until 1994 when all systems were assigned a single point of contact. In early 1995, cognizant ownership of these systems was assigned to Tank Waste Remediation System (TWRS) Materials and Corrosion Engineering (M&CE). In addition, other CP systems existing at the PUREX, PFP and 222-S Laboratory facilities are being supported by TWRS M&CE. This allows all individual systems to be monitored as a complete system. Besides economic benefit, single ownership is beneficial as systems in proximity may impact each other by the formation of stray currents. One responsible individual can best organize the systematic testing.

This report is the first 'Annual Cathodic Protection Survey Report for the Hanford 200 Area' for all of the Hanford 200 Area cathodic protection systems except those associated with B-Plant. This report encompasses test work collected in 1994, 1995, and up to midway of 1996.

1.1 Principals of Cathodic Protection

All buried transfer lines at Hanford experience environments which may be detrimental to the lines due to soil corrosion. Corrosion is an electrochemical reaction of a metal structure exposed to an electrolyte, similar to an operating battery. Metal dissolves at the anode metal surface with electrons flowing to the cathode through the metal itself. Ionic current flows through the electrolyte.

There are several methods of protecting buried structures, such as material selection and application of coatings. One widely accepted method of corrosion protection in industry and at Hanford is the application of cathodic protection. Cathodic protection is the use of direct current electricity from an external source to mitigate corrosion by opposing the discharge of corrosion current. When cathodic protection is installed for maximum corrosion protection, all portions of the protected structure collect current from the surrounding environment and the entire exposed surface becomes "cathodic."

1.2 Cathodic Protection at Hanford

The processing and waste storage facilities at the Hanford site are interconnected through a vast underground transfer system network. The transfer systems are primarily constructed of carbon steel and stainless steel. The soil burden covering the transfer systems provide the necessary radiation protection (shielding). The moist soil is corrosive to the steel transfer systems, with leaks being reported in the past. Corrosion protection of the piping is necessary to assure continued leak tightness. Furthermore, hazardous waste lines are required per Washington Administrative Code (WAC) to be protected from corrosion.

Cathodic protection of transfer lines at Hanford has existed since the late 1940's. The initial installations were to protect direct-buried stainless steel lines. These lines were reportedly failing from severe pitting corrosion (Jaske, 1954). The original CP systems were evaluated in 1980 by Battelle Columbus Laboratories (Payer, 1980). The study recommended that the operation of the CP systems be discontinued due to their age, condition, and very limited capabilities of evaluating operation. A replacement cathodic protection system was designed utilizing current technologies. Test stations were incorporated for evaluating the system operations to assure corrosion protection was being provided. Cathodic protection is only capable of protecting the outer surfaces of the transfer lines and not the inner walls from process side corrosion.

Eighteen tank farms exist at Hanford. Cathodic protection is applied to the transfer systems in ten of the tank farms. All of the double shell tank farms have cathodic protection. Selected single shell tank farms have cathodic protection. CP is operating on the transfer lines that run between the tank farms and five operating facilities. CP is operating on the transfer lines that run between one tank farm and another tank farm. Between July, 1994 and May, 1996, there were 33 individual rectifiers protecting the transfer systems and over 500 test stations were available for monitoring the CP systems' performances. Each test station is capable of supporting up to eight individual buried lines.

Beginning in the mid-1980's, the existing CP systems were installed at Hanford under several major projects over a series of years. New CP systems are being installed during 1996. The complete CP system has been installed with the intent of individual systems operating independently. All systems and related components, with the exception of the permanent reference electrodes, were designed with a minimum 20-year life expectancy.

Each CP system has a current source consisting of a silicon diode rectifier. All rectifiers at Hanford, at year ending 1995, were manufactured by Good-All Electric, Incorporated of Fort Collins, Colorado. The enclosed oil-immersed design provides protection from dust and sand. Most rectifiers are supplied by 3-phase 480 volt AC current. Several 120 and 220 volt input rectifiers exist at Hanford. Each unit is manually adjusted by changing the transformer taps that are located on a panel above the oil reservoir. The purpose of the rectifier is to step down the local AC power and convert it to a lower voltage DC output.

The anodes are the earth contacting electrodes through which the DC current is transmitted. The DC current that flows through the earth is picked up by the underground structures. The rectifier negative return cable(s) that are attached to the buried structures close the electronic/ionic circuit loop.

Typically, eight-inch diameter silicon cast iron anodes, mostly 96 inches long, are employed. Newer system designs are installing 48 inch long anodes. The anodes are prepackaged in a coke breeze backfilled canister. The anode canisters are 30 gauge galvanized stove pipe. Operation of the CP system will corrode away the stove pipe and allow the coke to provide the electrical contact with the soil.

The CP design at Hanford is of a distributed anode bed system. Anodes are installed either vertically or horizontally along the piping. The anodes installed over the waste tanks are horizontal. Anodes installed vertically provide protection to the piping around the entire circumference. The anodes are connected to a header cable. The cable is looped back to the rectifier for redundancy in the event the cable is severed. The anode header cable contains junction boxes at various locations. Cable branching allows some flexibility to adjust current flow. In some cases, anodes can be disconnected from the circuit to improve current distribution, reduce over-protection, or eliminate stray currents. The NEMA 4 anode junction boxes and anode distribution boxes incorporated in the system design contain eight electrically isolated terminal studs. Ten bus bars have been provided with each junction box assembly. The bus bars are used to interconnect the anode header and loop cables terminated on the studs. Surplus bus bars, if any, have been left in the bottom of each box for possible future use.

Test stations are installed at various locations along the transfer systems and are also installed adjacent to the waste storage tanks. The primary purpose of the test stations is to provide a means to measure structure-to-soil potentials. Each test station consists of a pair of wires (one #12 AWG and one #6 AWG). The wires are connected to the separate pipes that are designated to be monitored. The pair of wires are brought to the surface and terminated in a test box. Each test box is located in a buried enclosure with the top of the enclosure slightly above grade. Each lead is marked by a plastic tag identifying the pipe to which it is attached. Permanent reference electrodes are installed along the piping systems and these electrodes may be used when taking pipe-to-soil potential measurements. Test leads from the permanent reference electrodes, also identified with tags, are routed to the test stations.

Test leads are also attached on piping that is not intended to be protected. The purpose of these leads is to evaluate for stray currents. If a non-protected structure picks up stray currents, accelerated corrosion will occur at the point where the current is discharged. If stray currents are located, the piping can easily be bonded within the test box. A test lead from the piping that is picking up stray current will be connected to one of the test leads that is attached to a protected pipe. This will mitigate the accelerated corrosion by providing a metallic current path back to the rectifier.

Stray currents migrating underground may be detrimental to isolated metallic structures. These currents can develop from the operating CP systems or from other grounded electrical sources. Where an electrically discontinuous foreign structure in a voltage gradient becomes a conductor of DC current, the current is picked up by the foreign structure near the anodes or other high voltage source and discharges near the cathode or other low voltage area. The damage becomes evident in the form of accelerated corrosion which occurs where the stray current discharges from the foreign structure. The accelerated corrosion rate will reduce the useful life of the structure.

Stray current effects can be mitigated by incorporating the foreign structure into the CP system. This is easily achieved by providing direct bonds, resistor bonds, or diode bonds. These bonds allow the current to drain from the isolated structures. Sacrificial anodes can also be used in some situations as a current drain source when a mechanical bond is not wanted or feasible.

One method not recommended to reduce the probability of stray currents from the CP system involves abandoning existing anodes near the foreign structure. This will prevent the creation of voltage gradients but will reduce the current flow to the piping that was intended to be protected.

Color coding of the test leads in each test box generally exist. In most cases, the color coding is as described below:

Test Lead	Installed Location
#12 red	Piping designated to receive CP
#6 white	Piping designated to receive CP
#12 Blue	Piping not designated to receive CP
#6 Blue	Piping not designated to receive CP
#12 Green	Permanent reference electrode
#8 Black	Permanent reference electrode

Test stations are also installed adjacent to waste storage tanks. Two deep reference electrode lead wires terminate in the test boxes. The deep permanent reference electrodes installed adjacent to the waste storage tanks allow monitoring of tank potentials. One reference electrode is installed at a depth of 10 feet and the other at 25 feet. Wires would have to be manually attached to the tank structure at these test locations for the purpose of measuring the electrical potentials on the tanks.

The voltage data collected at the test stations provide the information necessary to assure that the buried structures are being adequately protected.

Table 1 identifies the 200 area cathodic protection systems that were operating in 1995 and early 1996.

Table 1: 200 Area Cathodic Protection Systems

Rectifier	Location	Lines Protected	Date Installed	Associated Area(s)
2	200E	V021/022/023/714	1985	202-A Bldg. to AW farm
7	200E	V714/713, PW-4509, SL-500, SN-600 S609/D603/4607, PW-4507/4508 PW-4526/4550/4608	1985/ 1991	241-AY Farm
8	200E	702A Vent Header	1987	241-AY Farm
9	200E	SL-100/101/500, SN-247/600, DR-314/326, DR-327	1991	241-AX Farm

Table 1: 200 Area Cathodic Protection Systems				
Rectifier	Location	Lines Protected	Date Installed	Associated Area(s)
10	200E	SN-247, CNDS-02/92	1991	241-A-401 Condenser and 241-AX Farm
11	200E	PSW-S608/S609/D603 /4607,PW-4507/4508 SL-160/500, SN-600	1985/ 1991	241-AN to 241-AZ Farms
12	200E	SN-247, CNDS-02/92	1991	241-A Complex
13	200E	SL-160/161/162 SL-164/165/166 SL-167/168, SN-247 SN-260/261/263, SN-264/265/266 SN-267, CNDS-02/92	1991	241-AN Farm
14	200E	V714, SN-215/216 SL-100/101, DR 314	1985/ 1991	241-A to 241-AY Farm
15	200E	SL-100/101, DR 314	1991	241-A Farm
16	200E	V714, SN-215/216, 4001, 4004, 702, PAW/NHW 4006/4018, PAW/NHW 4002/814/4015	1985	241-AW Farm, 204-AR
17	200E	SN-215/216	1985	244-AR Tank Vault
18	200E	SL-113/167/168, SN-215/216/219, SN-220/259/270, DR-334/335/343, 702, 4001, 4004	1985	242-A Building
19	200E	SL-161/162/163 SL-164/165/166 SL-167/168/169 SN-261/262/263 SN-264/265/269 SN-270/271/219 SN-220/266/267 SN-268/272/610, DR-334/335/343	1985	241-AW Farm
22	200W	202, 203	1992	241-Z to 241-TX Farms
23	200W	202, 203	1993	241-Z to 241-TX Farms

Table 1: 200 Area Cathodic Protection Systems

Rectifier	Location	Lines Protected	Date Installed	Associated Area(s)
24	200W	Drain Line	1993	251-U-151/152/153 Diversion Box to 241-U-301 Catch Tank
25	200W	SL- 101, SN-216, SN-282, DR-327	1993	Between 241-U and 241-SX/SY Farms
26	200W	SN-283/284	1993	242-S Evaporator to 02E Pump Pit above 241-SY-102
27	200W	V-560/561/562	1993	241-SY Farm to 244-S Receiver and 241-S-151 Diversion Box
31	200E	SL-100/101/502 SL-504/505, PW-4523/4526/4531, DR-314/327/370 and Annulus Vent Pipes Around 241-AY-101, and 241-AY-102	1991	241-AY Farm to 241-AX A&B Vaults
33	200E	GR-200, -202, -203 EW-200, -202, -203	1991, turned off in 1996	Grout
34	200W	V-387/398/404, DR-820	1993	Process Lines near 244-TX-152 Diversion Box
35	200W	SN-216/282, SL-101, DR-327, drain line	1993	241-U Farm
36	200W	SL-175/177/178 SL-179/180, SN-277/278/279 SN-280/282/283 SN-284/285/286 V561, V562, DR327	1996	241-SY Farm
37	200W	202, 203	1993	Saltwell receiver in 241-TX Farm
40	200E	GR-300, -304, -305 EW-300, -304, -305	1991, turned off in 1996	Grout
44	200W	Laboratory upgrade ducting, DR-1, -2	1995	222-S

Table 1: 200 Area Cathodic Protection Systems				
Rectifier	Location	Lines Protected	Date Installed	Associated Area(s)
45	200W	LSW, HSW and Spares	1994	PFP
R1	200E	SL-510/509/610/609/515/517 SN-615/617	1985	241-AP
R2	200E	SL-518/516 SN-618/616	1985	241-AP
RB220	200E	V720	1987	244-AR, AY Farm
EN-RECT-5745	200W	WT-5701/5702/5703/5704	1996	222-S

1.3 Washington State Cathodic Protection Requirements

The Hanford hazardous waste storage facilities are currently operating under an interim status permit from the Washington Department of Ecology. Eventually the Hanford site will be issued a final status permit. At this time the Hanford site will begin operating as a permitted Dangerous Waste Storage Facility. The Washington Administrative Codes will likely apply to the hazardous waste storage facilities. WAC 173-303-640 requires corrosion protection of the waste storage and transfer system.

Impressed current CP existing on Hanford's underground transfer systems mitigates corrosion. Periodic assessment of the CP system operation is required and necessary to assure the systems are operating and to assure that adequate corrosion protection is applied to the buried structures. Bimonthly rectifier checks and annual CP surveys are mandated by the State of Washington per WAC 173-303-640.

1.4 Cathodic Protection Survey Procedure

The primary objective of performing CP surveys is to ensure that adequate corrosion protection is provided on the designated piping. Cathodic protection surveys were performed per Tank Farm Maintenance Procedure 6-TF-357, Testing of Cathodic Protection System. The rectifiers were visually examined for physical damage, rectifier oil cleanliness, and oil level. All panel meters were checked for calibration as compared to a calibrated portable multimeter. All voltage readings were taken across the anode (+) and cathode (-) terminals. The output current was determined by reading the voltage drop in millivolts across the calibrated shunt and converting to amperes using Ohm's Law (V=IR).

Pulse generators were installed in series with all nearby rectifier units prior to pipe-to-soil potential measurements. The pulse generators provide a synchronized interruption of all nearby anode currents. Current flowing during the test will affect the measured voltage by adding an extraneous voltage to the pipe-to-soil potential values. The interrupted currents generated by the rectifier-pulse generator series circuit create pipe-to-soil potentials on the piping with no extraneous soil voltage drop to measure. The soil voltage drop is caused by the flow of DC current flow through the soil. The current free potential measurement is called the polarized pipe-to-soil potential.

Continuity tests were performed to identify those structures and test leads not continuous with the system. These tests were performed by measuring the resistance between both test leads from each pipe and measuring the resistance between the different pipes.

Potential readings were measured at selected test stations on selected structures. These structures were identified before the testing and after a review of previous CP survey data and system drawings. All potential readings were measured with a high impedance waveform analyzer relative to a portable copper/copper sulfate reference electrode. Selected permanent copper/copper sulfate reference electrodes were also utilized. The waveform analyzer was used to measure the resulting IR error free structure-to-soil potentials. The wave form analyzer detects the pulse-generated interruptions and processes the "ON" and "OFF" (IR error free) potentials.

The operating criteria to which the cathodic protection systems are evaluated is the NACE recommended practice RP0285-95, "Corrosion Control of Underground Storage Tank Systems by Cathodic Protection". Two of the acceptance criteria specified in NACE RP0285-95 are used as standards at Hanford. The widely accepted criterion of a polarized pipe-to-soil potential of -0.85 volt DC, relative to a copper/copper sulfate reference electrode, on buried steel structures is considered the most conservative standard in use at Hanford. The potential measured during the "OFF" cycle generated by the pulse generator-rectifier series arrangement represents the IR-error free (polarized) structure-to-soil potential.

A second criterion to which cathodic protection is considered protective is described in RP0285-95 as the 100 mV potential shift. A structure is considered protected from corrosion if a measurable potential shift of 100 mV or more in the negative direction occurs upon system energization. For practical application at Hanford, this occurs when the instant "OFF" potential is at least 100 mV more negative than the "NATIVE" potential.

The complex configuration of the tank farms transfer systems with different material types, different construction designs, and proximity to large structures, such as waste tanks or valve pits, creates different current requirements and polarization rates. The NACE criteria, which serves as a guide for evaluating the operation of CP systems, is not universal for all structures and environments. These criterion are more directed at ideal hypothetical conditions of a single metal exposed to a uniform homogeneous environment, which does not exist at Hanford. The most conservative approach presented in NACE Recommended Practice RP0285-95 is to utilize the most anodic metal and proceed to achieve a sufficient potential to polarize the cathode to the open circuit potential of the most anodic material. The supplied current assures a level of protection to the less anodic materials.

Since carbon steel is considered the most anodic material buried at Hanford, the -0.85 volt criteria approximates the protection requirement criteria to achieve total corrosion mitigation. The difficulty with this value is the complex configuration of the tank farms. Near the tanks that have reinforced concrete, the potential achieved will generally be less than at remote locations or even near different materials such as stainless steel structures. Considerable testing would be required to determine the actual protection criteria for the multitude of conditions and locations. Measured potentials near the large structures are usually found more positive (i.e., -0.50V) than the -0.85 criteria. Arbitrarily increasing the rectifier outputs to make this potential more negative to meet the -0.85 volt criteria may cause more harm than good and possibly damage the tank components. Investigations are required to evaluate the more positive potentials near the tanks and other large structures and to determine the impacts of increasing the rectifier outputs. The 100 millivolts shift criteria is the established standard of judgement that is being used at Hanford when the -0.85 polarized potential is not being realized.

Earlier cathodic protection surveys identified several permanent copper/copper sulfate reference electrodes as being questionable references. A difference in potentials between the permanent and portable reference electrodes was noted in several cases. Only a very minute difference should exist between the two reference electrodes. This is due to the resistance of the separating soil. The higher than anticipated potential difference may be due to aging of the permanent reference cells, or dry soil, or other physical conditions. Significant differences (greater than 0.1 VDC) indicate that data obtained with the permanent reference electrode is questionable.

2.0 1995 ANNUAL CATHODIC PROTECTION SURVEY RESULTS

Results of the CP surveys performed during calendar year 1995 are presented in the following sections. The pipe-to-soil potential data is presented in tables 2 through 12. Structures that did not meet the standard - 0.85 V criterion have been undergoing evaluation for meeting the - 100 mV potential shift criterion or have had the rectifiers adjusted. Since the whole system is still in the process of being optimized, no exceptions are explicitly called out in this report.

2.1 200 East Tank Farms

The standard cathodic protection surveys were not performed in the A-Tank Farm Complex due to the construction activities related to the W-030 and the W-320 projects. The resurvey of January, 1995 of the A complex was conducted at key test stations. Results of the 1995 resurvey are documented in 'Cathodic Protection System Resurvey' and this survey was accomplished by Corrpro Companies, Inc.

The construction activities de-energized many of the rectifiers in the A-Complex and AN Tank Farm. The excavation activities dislocated several test stations and anodes. The results of any survey performed during the construction activities would not encompass the influence of the separate CP systems upon each other. The standard complete survey is to be performed upon completion of the Projects. The Projects' CP operational test procedures are to be performed in conjunction with the CP surveys.

2.2 242-A Evaporator

The Evaporator CP systems, specifically those associated with the AP tank farm (Rectifier R1 and R2) and AW tank farm (Rectifier 19), were surveyed in association with the PUREX facility. The annual survey requires coordination with the PUREX facility and installation of test equipment on all nearby rectifiers. The nearby rectifier systems may affect each other by generating inadvertent stray currents on the piping where the potentials are measured at the test stations. The rectifiers possibly affecting each other are those in and nearby the AP and AW Tank Farms and the PUREX facility. The systems north of the Evaporator were not surveyed due to the aforementioned construction activities in the A-Tank Farm Complex. These systems will be surveyed as a complete system upon completion of the W-030 and W-320 projects.

The CP systems provide corrosion protection to the underground transfer lines within the AP and AW tank farms. Besides these lines in the farms, other lines in the vicinity may be electrically connected to the system and may be picking up protective CP currents.

Pulse generators were installed on Tank Farm's Rectifiers 19, R1, and R2 and on PUREX's Rectifier 2. These rectifiers protect transfer lines in the AW-Tank farm area and the AP Tank Farms area and the PUREX facility area. These rectifiers, pulsing in synch, interrupt all nearby underground currents that may influence the measured potentials. The instant "OFF" (polarized) potentials provide an accurate assessment of the degree of corrosion protection provided to the buried transfer lines. A wave form analyzer (WFA) was used to measure the "ON"/"OFF" potentials. The WFA captures both the high and low pipe-to-soil potentials representative of the on/off cycles of the pulse generators.

SURVEY RESULTS AND DISCUSSION

Each of the rectifiers is a standard oil-filled rectifier operating under constant DC voltage. The rectifiers were visually inspected and found in good condition. The rectifier oil appeared clean, in good condition, and at the proper level. No oil leaks from the rectifiers were found. During the wet spring of 1995 Rectifier 19 was continuously over-amping the fuse device. This was due to circuit overloads. The tap settings had been adjusted as high as possible. This was the recommendation of the baseline July 1994 survey. The taps were reduced from D-1 to C-2 prior to surveying. Monitoring assured the rectifier remained operational. The operational characteristics of the rectifiers prior to performing the surveys are provided below:

Rectifier 19
Make: Good-All Electric
Model: CSOYTF 40-12 ENTZ
Serial #: 85C2858
Part #: 0030537
Rectifier Input: 480 volts (AC), 0.75 amps
Maximum Rectifier Output: 40 volts (DC), 12 amps
Taps (as found): C-2

	Panel Readings
Rectifier Output:	26 VDC
Current (as found):	13 amps

Shunt: 100 amps @ 50 mVolts

Rectifier R1
Make: Good-All Electric
Model: CSOYTD 100-60 EGNZ
Serial #: 85C2388
Rectifier Input: 480 volts (AC), 8.6 amps
Maximum Rectifier Output: 100 volts (DC), 60 amps
Taps (as found): B-1

	Panel Readings
Rectifier Output:	32 VDC
Current (as found):	24 amps

Shunt: 80 amps @ 50 mVolts

<u>Rectifier R2</u>
Make: Good-All Electric
Model: CSOYTD 100-60 EGNZ
Serial #: 85C2389
Rectifier Input: 480 volts (AC), 8.6 amps
Maximum Rectifier Output: 100 volts (DC), 60 amps
Taps (as found): D-2

	Panel Readings
Rectifier Output:	92 VDC
Current (as found):	35 amps

Shunt: 80 amps @ 50 mVolts

The key test stations within the tank farms were selected for testing. These test stations were selected by analyzing previous data and by reviewing the configuration drawings. The pipe-to-soil potentials were measured with a portable reference cell rather than the permanent reference cells. The portable reference cell is considered more accurate than the older deteriorating permanent cells.

The results of the surveys in AP and AW Tank Farms are presented in Table 2 and Table 3 respectively. These results are compared to those measured during the baseline CP survey (4/94-6/94) and compared to a re-survey that was performed in January of 1995.

Table 2. Pipe-to-Soil Potentials (VDC), AP Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
79-01	RW	-1.524	-1.012			-1.787	-1.130
78-03	SN-602 SL-509 SL-510 SN-609 3" RW	-1.992 -1.991 -1.990 -1.991 -1.992	-1.176 -1.177 -1.174 -1.176 -1.178			-2.542 -2.542	-1.268 -1.259
93-01	SN-650	-0.946	-0.598			-1.191	-0.726
80-07(A)	PW 812 RW-S AE INT SL-512 SN-612	-0.458 -0.454 -0.452 -0.452 -0.469 -0.461	-0.400 -0.400 -0.399 -0.400 -0.402 -0.399			-0.699 -0.656	-0.551 -0.553
80-7(B)	RW-N SN-622 SN-621	-0.453 -0.459 -0.447	-0.400 -0.398 -0.412			-0.654 -0.672	-0.548 -0.554

Table 2. Pipe-to-Soil Potentials (VDC), AP Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
80-24	SN-621	-2.962	-1.195			-4.336	-1.549
80-23(A)	RW-S INT T23 ANN EXH RW-N SN-614 PW-814	-0.501 -0.501 -0.500 -0.500 -0.501 -0.500	-0.386 -0.387 -0.387 -0.387 -0.387 -0.386	-0.868 -0.868 -0.867 -0.868 -0.869 -0.869	-0.548 -0.548 -0.547 -0.552 -0.552 -0.545	-0.890 -0.891	-0.635 -0.637
80-23(B)	SN-621	-0.501	-0.385	-0.870	-0.550	-0.895	-0.639
81-18(A)	AE 104 AE 103 PE 104 PE 103 PE 102 PE 101	-0.795 -0.797 -0.797 -0.797 -0.797 -0.797	-0.488 -0.489 -0.489 -0.490 -0.487 -0.490			-1.430 -1.432	-0.594 -0.643
81-18(B)	AE 102 AE 101	-0.797 -0.795	-0.489 -0.488			-1.429 -1.429	-0.643 -0.637
81-19	RW PE 6" EM 26 4" OVERFLW	-0.888 -0.889 -0.889 -0.888	-0.761 -0.759 -0.758 -0.758			-1.267 -1.265	-0.956 -0.949
81-10(A)	AE 107 AE 106 AE 105 AE 108 PE 106 PE 105	-0.729 -0.729 -0.728 -0.729 -0.729 -0.729	-0.519 -0.519 -0.519 -0.516 -0.516 -0.516			-1.214 -1.214	-0.735 -0.738
81-10(B)	PE 108 PE 107	-0.729 -0.729	-0.515 -0.515			-1.214 -1.214	-0.738 -0.735
82-06(A)	PW 816 SN-616 SL-516 RW-N RW-S INT	-0.888 -0.888 -0.888 -0.887 -0.887 -0.888	-0.679 -0.677 -0.679 -0.677 -0.679 -0.678	-1.812 -1.812 -1.812 -1.809 -1.809 -1.809	-0.979 -0.973 -0.973 -0.978 -0.981 -0.977	-1.263 -1.263	-0.903 -0.896
82-06(B)	AE	-0.887	-0.681	-1.809	-0.977	-1.262	-0.900
82-07	AE 106 AE 108 PE 108 SL-518 SN-618 INT EXHAUST	-1.501 -1.505 -1.504 -1.507 -1.506 -1.505 -0.713	-1.048 -1.049 -1.048 -1.045 -1.049 -1.047 -0.381			-2.005 -2.005	-1.179 -1.179
82-13(A)	RW-N SN-518 RW-S AE INT PW	-0.722 -0.722 -0.722 -0.721 -0.721 -0.721	-0.610 -0.606 -0.611 -0.608 -0.606 -0.612			-1.165 -1.166	-0.873 -0.875

Table 2. Pipe-to-Soil Potentials (VDC), AP Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
82-13(B)	SN-618	-0.722	-0.612			-1.162	-0.879
82-10	SN-617	-1.690	-0.938			-2.783	-1.188
	SL-517	-1.691	-0.936			-2.784	-1.183
	AE	-1.690	-0.933				
	PE	-1.690	-0.934				
	INT	-1.689	-0.936				
82-03	V M22	-1.437	-0.690			-1.989	-0.820
	PW 825	-1.438	-0.688			-1.992	-0.825
82-01(A)	PW 825	-0.580	-0.417			-0.709	-0.494
	RW N	-0.579	-0.413			-0.708	-0.495
	INT	-0.579	-0.412				
	PW 815	-0.579	-0.411				
	RW S	-0.578	-0.413				
	AE	-0.579	-0.412				
82-01(B)	SN-615	-0.580	-0.417			-0.710	-0.498
	SL-515	-0.580	-0.415			-0.711	-0.500
82-02(A)	SN-617	-1.617	-1.134			-1.937	-1.124
	INT	-1.615	-1.134			-1.937	-1.126
	2" RW	-1.626	-1.132				
	SN-615	-1.617	-1.132				
	SL-517	-1.618	-1.132				
	SL-515	-1.617	-1.129				
82-02(B)	PE 105	-1.616	-1.133			-1.938	-1.124
	AE 107	-1.629	-1.132			-1.939	-1.132
	AE 105	-1.617	-1.136				
	PE 107	-1.617	-1.130				
81-05(A)	SN-618	-1.378	-0.805	-1.757	-0.894	-1.769	-0.844
	SN-617	-1.377	-0.805	-1.756	-0.895	-1.769	-0.847
	SN-616	-1.378	-0.807	-1.757	-0.894		
	SL-513	-1.382	-0.805	-1.768	-0.895		
	SL-514	-1.381	-0.806	-1.767	-0.899		
	SN-615	-1.378	-0.806	-1.757	-0.899		
81-05(B)	SL-512	-1.394	-0.806	-1.792	-0.901	-1.820	-0.854
	SL-511	-1.383	-0.807	-1.771	-0.900	-1.789	-0.859
81-02(A)	SN-616	-0.590	-0.465			-0.753	-0.515
	SN-615	-0.590	-0.467			-0.751	-0.513
	SN-614	-0.591	-0.467				
	SN-611	-0.591	-0.468				
	SN-612	-0.591	-0.466				
	SN-613	-0.589	-0.467				
81-02(B)	SN-618	-0.588	-0.467			-0.753	-0.517
	SN-617	-0.586	-0.466			-0.751	-0.514
	DR-712	-0.589	-0.441				
	DR-713	-0.590	-0.465				
	2" FL	-0.589	-0.466				

Table 2. Pipe-to-Soil Potentials (VDC), AP Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
80-13(A)	PW 813	-0.472	-0.393			-0.616	-0.499
	INT	-0.472	-0.396			-0.614	-0.503
	ANN EXH	-0.471	-0.396				
	RW-N	-0.472	-0.391				
	RW-S	-0.472	-0.391				
	PW 823	-0.472	-0.390				
80-13(B)	SN-613	-0.474	-0.392			-0.616	-0.503
	SL-513	-0.474	-0.392			-0.620	-0.504
80-14	INT	-2.212	-1.096			-2.750	-1.138
	ANN EXH	-2.212	-1.092			-2.751	-1.148
	PRI EXH	-2.210	-1.087				
	SN-613	-2.212	-1.091				
	SL-513	-2.212	-1.089				
80-21	PRI EXH	-1.805	-1.103			-3.449	-1.766
	ANN EXH	-1.835	-1.101			-3.453	-1.766
	SN-612	-1.813	-1.103				
	SL-512	-1.838	-1.102				
	INT	-1.802	-1.103				
80-04	SL-511	-1.450	-0.758			-1.579	-0.833
	INT-1	-1.449	-0.755			-1.574	-0.827
	ANN EXH	-1.449	-0.759				
	PRI EXH	-1.449	-0.756				
	INT-2	-1.450	-0.757				
	SN-611	-1.451	-0.761				
80-16	RW	-1.276	-1.000			-1.706	-1.102
	DR 714	-1.273	-1.007			-1.705	-1.095

TABLE 3. Pipe-to-Soil Potentials (VDC), AW Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
33-36(1)	IA #2	-1.114	-0.678			-1.367	-1.055
	S-100	-1.111	-0.684			-1.363	-1.058
	RW	-1.109	-0.677				
	IA #3	-1.114	-0.680				
	PA	-1.115	-0.682				
33-36(2)	PA	-1.116	-0.684			-1.384	-1.042
	IA	-1.113	-0.682			-1.380	-1.059
	1/2" #1	-1.115	-0.679				
	1/2" OA #4	-1.114	-0.682				
	6 Cu LINES	-1.113	-0.686				
33-34	DR-371					-1.930	-1.390
	RW					-1.914	-1.382
33-35	SL-167	-2.037	-1.099			-1.929	-1.391
	SL-168	-2.036	-1.099			-1.929	-1.393
	SN-219	-2.037	-1.092				
	SN-269	-2.038	-1.088				
	SN-270	-2.048	-1.091				
	SN-220	-2.038	-1.102				
77-01(#1)	SN-610	-2.287	-1.169			-2.542	-1.268
	SN-609	-2.286	-1.167			-2.548	-1.272
	V005	-2.285	-1.165				
	V007	-2.284	-1.166				
77-01(#2)	SL-510	-2.283	-1.171			-2.546	-1.271
	SL-509	-2.288	-1.168			-2.546	-1.270
	DR-374	-2.287	-1.167				
33-02	DR 374			-1.237	-0.786	-1.237	-0.786
	V005	-1.091	-0.778	-1.247	-0.786	-1.247	-0.786
	V007	-1.092	-0.780				
33-12	8" EXH	-1.093	-0.782			-1.248	-0.784
	DR 361	-1.092	-0.782				
	IA					-1.241	-0.783
33-32(#1)	DR 361			-2.253	-1.076	-1.233	-0.792
	10" INTAKE			-2.254	-1.082	-1.234	-0.793
	IA-A			-2.251	-1.076		
	SN-268	-0.966	-0.709	-2.253	-1.076		
	IA-B	-0.961	-0.702	-2.251	-1.070		
	IA-C			-2.252	-1.074		
33-32(#2)	10" EXH					-1.234	-0.795
	PA	-0.966	-0.708			-1.235	-0.790
	IA-A						
	IA-B						
	SN-267						
33-30	DR 361	-1.672	-0.913				
	SN-262	-1.670	-0.915				
	SL-162						
	IA					-2.059	-0.994
	8" EXH					-2.065	-0.994

TABLE 3. Pipe-to-Soil Potentials (VDC), AW Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
33-32	S-100					-1.427	-0.876
	SL-167					-1.429	-0.876
	SN-219	-1.116	-0.775				
	2N-268	-1.117	-0.775				
33-47	SL-509	-1.325	-0.703			-1.934	-0.916
	SL-164	-1.322	-0.699			-1.930	-0.915
	SL-166	-1.322	-0.700				
	SL-510	-1.324	-0.705				
77-04	12" V (A)	-1.319	-0.757			-1.655	-0.866
	12" V (B)	-1.319	-0.757			-1.653	-0.865
	12" V (C)	-1.316	-0.750				
	SL-509	-1.322	-0.760				
	SL-510	-1.321	-0.758				
33-14	PW 464	-0.888	-0.661			-0.697	-0.541
	PW-474	-0.888	-0.664			-0.699	-0.544
	10" EXH						
33-15	SN-274					-0.700	-0.542
	10" EXH					-0.700	-0.543
	SL-164	-0.888	-0.657				
	SN-264	-0.889	-0.661				
33-24	12" VENT					-1.272	-0.657
	14" VENT					-1.273	-0.654
	SL-166	-0.957	-0.537				
	SN-266	-0.959	-0.542				
33-07	10" EXH	-0.527	-0.396			-0.744	-0.500
	PW 476	-0.527	-0.398			-0.746	-0.506
	PW 466	-0.528	-0.398				
33-08	SL-166	-0.483	-0.392			-0.748	-0.508
	SN-266	-0.483	-0.392			-0.748	-0.506
33-23	8" INTAKE			-1.597	-0.750	-1.029	-0.560
	SN-266	-0.815	-0.452	-1.599	-0.753	-1.031	-0.560
	SL-166	-0.813	-0.447	-1.600	-0.753		
33-05	PW 465	-0.470	-0.372			-0.452	-0.368
	PW 475	-0.470	-0.372			-0.454	-0.368
33-42(#1)	14" EXH	-1.486	-0.593			-1.806	-0.720
	12" EXH	-1.486	-0.592			-1.807	-0.723
	12" M42 EXH	-1.488	-0.592				
	SL-165	-1.485	-0.593				
33-42(#2)	12" M42 EXH	-1.484	-0.593			-1.808	-0.723
	IA	-1.486	-0.592			-1.807	-0.723
	SN-265	-1.486	-0.592				
33-11	IA			-3.820	-1.163	-1.900	-0.878
	6" UNKNOWN	-1.604	-0.761	-3.821	-1.161	-1.901	-0.879
	5-1/2" Cu			-3.820	-1.156		
	SL-165	-1.593	-0.762	-3.825	-1.169		
	SN-265			-3.827	-1.160		
	10" EXH			-3.823	-1.161		

TABLE 3. Pipe-to-Soil Potentials (VDC), AW Tank Farm

Test Station	Buried Structure	July, 1994		January, 1995		August, 1995	
		ON	OFF	ON	OFF	ON	OFF
33-28(#1)	7-1/2" AIR (A)					-2.495	-1.277
	7-1/2" AIR (B)					-2.496	-1.277
	7-1/2" AIR (C)						
	SL-165	-1.545	-0.996				
	SN-263	-1.542	-0.995				
33-28(#2)	IA					-2.494	-1.270
	12" VENT					-2.495	-1.274
	1/2" AIR						
	SN-265	-1.546	-0.995				
33-16	SL-510					-0.654	-0.406
	SL-165					-0.655	-0.404
	SL-161	-0.820	-0.577				
	DRAIN 361	-0.821	-0.578				
	SL-163						
33-17	SL-168	-0.822	-0.575			-0.657	-0.403
	SN-220	-0.822	-0.579			-0.657	-0.402
	SN-267						
33-25	10" EXH					-1.525	-0.654
	SN-261	-1.026	-0.543			-1.526	-0.651
	SL-161	-1.024	-0.542				
33-26	IA					-1.524	-0.650
	PW-471	-1.022	-0.537			-1.524	-0.650
	PW-461	-1.025	-0.543				
33-27(#1)	SN-220	-1.446	-0.766			-1.873	-0.900
	SL-167	-1.442	-0.766			-1.874	-0.900
	SL-168	-1.444	-0.769				
	SN-219	-1.443	-0.766				
33-27(#2)	IA					-1.868	-0.899
	SN-270	-1.448	-0.759			-1.874	-0.900
	SN-269						

The measured potentials in both tank farms were observed at a more negative value than the potentials which were recorded during the baseline survey. The rectifiers' tap setting were adjusted after the baseline survey of 1994. All the structures in AP farm that were tested and all but four of the structures in AW farm that were tested were protected to one of the following criteria: a more negative potential than -0.85 volts; a polarization voltage of at least 100 millivolts more negative than the 7/94 survey potentials; or 100 millivolts polarization more negative than the native potentials. No adjustments were made to rectifiers R1 and R2. These rectifiers serve AP farm. The four structures in AW farm receiving less than 100 millivolts of polarization were polarizing to between 66 to 79 millivolts. Rectifier 19 was not adjusted to a higher tap setting. This rectifier was already running at its maximum amperage.

2.3 PUREX Facility

The PUREX cathodic protection (CP) system associated with Rectifier 2 was surveyed per Engineering Task Plan PUREX Cathodic Protection System Maintenance (WHC-SD-WM-ETP-146). The PUREX annual survey requires coordination with Tank Farms to install test equipment on the nearby rectifiers that may affect each other by inadvertent stray currents.

The CP system provides corrosion protection to PUREX's underground transfer lines V021, V022, V023 and V714. Besides these lines, other lines in the vicinity may be electrically connected to the system and may be picking up protective CP currents.

In addition to Rectifier 2, pulse generators were also installed on Tank Farm's Rectifiers 19, R1 and R2. These rectifiers, pulsing in synch with Rectifier 2, interrupt all nearby underground currents that may influence the measured potentials. The instant "OFF" (polarized) potentials provide an accurate assessment of the degree of corrosion protection provided to the buried transfer lines.

These tests were performed on August 7 and 25, 1995 by PUREX Electrical Maintenance with support from TWRS M&CE. A wave form analyzer (WFA) was used to measure the "ON"/"OFF" potentials. The WFA captures both the high and low pipe-to-soil potentials representative of the on/off cycles of the pulse generators.

SURVEY RESULTS AND DISCUSSION

Rectifier 2, a standard oil-filled rectifier operating at constant voltage, was visually inspected and found in good condition. The rectifier oil appeared clean, in good condition, and at the proper level. No oil leaks from the rectifier were found. The operational characteristics of Rectifier 2 prior to performing the survey are provided below:

Rectifier 2
Make: Good-All Electric
Model: CSOYSF 120-65 ENTZ
Serial #: 85C2338
Part #: 0030095
Rectifier Input: 480 volts (AC), 11.1 amps
Maximum Rectifier Output: 120 volts (DC), 65 amps
Taps (as found): C-3

	Panel Readings	Meter (Portable) Readings
Rectifier Output:	88 VDC	87.5 VDC
Current (as found):	31 amps	30 amps

Shunt: 100 amps @ 50 mVolts

Before performing the survey, key test stations behind 202A Building were selected for testing. The key test stations represent the entire length of the protected transfer lines. The pipe-to-soil potentials were measured with a portable reference cell rather than the permanent reference cells that are installed in each test station. The portable reference cell was considered more accurate than the older deteriorating permanent cells.

The results of the survey are presented in Table 4 with the initial tap settings set at C-3. These results are compared to those measured during the baseline CP survey (6/94). The baseline tap settings were set at A-4.

Although the measured potentials became more negative when compared to the baseline survey potentials, the potentials at most test stations did not meet the -0.85 volt criteria. Following the survey, the tap settings were changed from C-3 to D-2 and the system was allowed to re-stabilize for two weeks. Afterwards, several test stations were reevaluated. The results of these tests are also presented in Table 4.

Table 4. Pipe-to-Soil Potentials (VDC), PUREX

Test Station	Buried Structure	Taps@ A-4		Taps @ C-3		Taps @ D-2	
		ON	OFF	ON	OFF	ON	OFF
35-08 (2)	V714	-0.544	-0.474	-0.783	-0.570		
	24" 8823 (1)	-0.526	-0.474	-0.744	-0.561		
35-09 (2)	V714 (sleeve)	-0.126	-0.083	-0.386	-0.233	-0.366	-0.258
	3" T053 (1)	-0.522	-0.467	-0.746	-0.564	-0.725	-0.565
	16" 8824 (1)	-0.526	-0.469	-0.746	-0.563	-0.732	-0.568
35-11	2" F602 (1)	-0.349	-0.320	-0.453	-0.390		
	24" 8823(1)	-0.349	-0.324	-0.469	-0.399		
	2" F127 (1)	-0.349	-0.321	-0.475	-0.403		
	6" Vent (1)	-0.346	-0.322	-0.479	-0.411		
	4" Vent (1)	-0.348	-0.321	-0.483	-0.413		
35-12	16" 8824 (1)	-0.638	-0.531	-1.311	-0.901	-1.371	-0.931

Table 4. Pipe-to-Soil Potentials (VDC), PUREX							
Test Station	Buried Structure	Taps@ A-4		Taps @ C-3		Taps @ D-2	
		ON	OFF	ON	OFF	ON	OFF
35-08 (2)	V714	-0.544	-0.474	-0.783	-0.570		
	4" WRAP (1)	-0.637	-0.536	-1.310	-0.907	-1.377	-0.933
	6" SC-BY (1)	-0.636	-0.535	-1.307	-0.910	-1.375	-0.937
	3" AMMONIA (1)	-0.632	-0.536	-1.274	-0.911	-1.332	-0.936
	12" SC HDR (1)	-0.638	-0.532	-1.312	-0.913	-1.388	-0.939
35-20	V022	-0.725	-0.479	-1.098	-0.614		
	V021	-0.732	-0.483	-1.103	-0.616		
	V714	-0.735	-0.481	-1.115	-0.617		
	V023	-0.728	-0.481	-1.096	-0.615		
	8" UI SW (1)	-0.686	-0.469	-0.968	-0.592		
	2" 060 (1)	-0.714	-0.476	-1.066	-0.603		
35-25	V022	-0.527	-0.445	-0.951	-0.656	-0.831	-0.600
	V021	-0.523	-0.439	-0.955	-0.657	-0.834	-0.604
	V714	-0.531	-0.443	-0.966	-0.657	-0.844	-0.602
35-25	V023	-0.531	-0.442	-0.959	-0.659	-0.828	-0.600
	30" 8023 (1)	-0.528	-0.438	-0.925	-0.651	-0.791	-0.590
35-40	3"M21	-0.520	-0.449	-0.868	-0.636		
	6" VENT (1)	-0.516	-0.441	-0.875	-0.641		
	4" W-LINE (1)	-0.516	-0.440	-0.881	-0.647		
	RW-M5 (1)	-0.515	-0.444	-0.890	-0.651		

Table 4. Pipe-to-Soil Potentials (VDC), PUREX

Test Station	Buried Structure	Taps@ A-4		Taps @ C-3		Taps @ D-2	
		ON	OFF	ON	OFF	ON	OFF
35-08 (2)	V714	-0.544	-0.474	-0.783	-0.570		
35-41	12" SC HDR (1)	-0.516	-0.442	-0.893	-0.657	-1.081	-0.728
	6" SC BY (1)	-0.515	-0.446	-0.892	-0.656	-1.093	-0.744
	3" AMMONIA (1)	-0.511	-0.445	-0.891	-0.663	-1.032	-0.716
35-54	30" 8823 (1)	-0.325	-0.324	-0.479	-0.416	-0.450	-0.394
	4"M21 (1)	-0.325	-0.324	-0.480	-0.416	-0.449	-0.396
35-60	V022	-0.605	-0.513	-0.907	-0.677		
	V021	-0.605	-0.512	-0.909	-0.678		
	V714	-0.610	-0.516	-0.925	-0.681		
	V023	-0.606	-0.512	-0.915	-0.679		
	T144 (1)	-0.586	-0.509	-0.882	-0.672		
35-61	V714	-0.390	-0.359	-0.776	-0.592		
	1-1/2" SCH 40 (1)	-0.376	-0.355	-0.736	-0.590		

(1) Per SD-WM-TI-276, Rev. 0, "Project B-234, Upgrade of Hanford Site 200 Areas Cathodic Protection Systems, Final Energization Report" these lines are reportedly not protected by the installed cathodic protection system.

(2) At test stations 35-08 and 35-09 the transfer line V714 is located within a sleeve and insulated from the sleeve with insulating spacers. The test leads are attached to the sleeve rather than to V714 transfer line resulting in more positive pipe-to-soil potential readings at these test stations.

The data in Table 4 shows that the transfer lines in Test Station 35-12 meet the -0.85 volt criteria. These lines were reported in project documentation as those not required nor intended to be protected by the CP system. These lines may not be intentionally bonded into the system and could be picking up stray currents. At most of the other test stations a potential shift of 100 mV on the piping was observed when the tap settings were changed from A-4 to C-3 and from A-4 to D-2. This shows that corrosion protection of these lines is provided per the 100 mV potential shift criteria. The lines not intentionally designed to be protected may be picking up stray currents if the lines are not bonded. However it is difficult to ascertain without further investigation. In test station 35-20, the 8" UI-SW line appears to be picking up stray current due to the more positive "OFF" potential relative to the other pipes.

Increasing the electrical output from the rectifier was deemed unlikely to polarize the potentials on the piping to a value as negative or more negative than the -0.85 volt criteria. The small differences observed in the "ON" and "OFF" potentials at test stations 35-11 and 35-54 show that these lines are not protected and are picking up almost no current.

2.4 200 West Tank Farms

The CP system in West Tank Farms is comprised of several subsystems. These subsystems are integrated into the West Area Tank Farm CP system. The protected transfer lines are largely electrically continuous. Some of the transfer lines run between farms and subsystems. Each subsystem consists of a rectifier unit, associated cables, anodes, and test stations.

There are a total of 13 rectifiers in 200 West Area. Ten rectifiers are owned by West Tank Farm Operations, two rectifiers are owned by 222-S Labs, and one rectifier is owned by the Plutonium Finishing Plant (PFP). Two new rectifiers were installed in early 1996, one at 241-SY Tank Farm and one at 222-S Labs. Table 5 lists the operational rectifiers at 1995 year-end in West Area Tank Farms and identifies the transfer lines protected. Rectifier 36 at 241-SY was brought online in January 1996. Document WHC-SD-430-OTR-001 Rev. 0, Operational Test Report for Project W-430, SY Farm Cathodic Protection, presents the performance of Rectifier 36.

Table 5. West Tank Farm Cathodic Protection Subsystems

RECTIFIER	LOCATION	PROTECTED SYSTEM
22	PFP, outside east fence	Lines 202/203 from PFP to 241-TX Tank Farm
23	Northwest Corner of TX	Lines 202/203 from PFP to 241-TX Tank Farm
24	16th and Camden	241-U-151 Diversion Box and assoc. lines
25	16th and Camden	Transfer lines from 242 Evap to 241-U Tank Farm
26	North of 241-SY	Lines from 242-S to S-152 and SL-175, -176 to 241-SY
27	NE of S-151 Diversion box	244-S Saltwell Receiver and S-151 Diversion Box to 241-SY
34	S of TX-152 Diversion box	Process lines surrounding TX-152 Diversion box
35	16th and Camden	Process lines from C and D valve pits and 244-U Vault
36	North of 241-SY	Process lines in 241-SY
37	North of 242-T	Lines to/from 244-TX Saltwell Receiver

SURVEY RESULTS

At the time of the survey, all rectifiers were found operating with the electrical output characteristics presented in Table 6. Historical rectifier outputs from July 1994 and January 1995 surveys are also provided for comparison. All of the rectifiers were found to be in good physical condition. The rectifier oil was found clean and no significant gasket rips were noted.

Variations in the rectifier outputs are noted from the data that is presented in Table 6. The changes in the rectifier outputs are largely due to the rectifier tap setting adjustments that were made following the July 1994 surveys. However, there are some variations in output without rectifier adjustments. These variations can be caused by a number of factors such as soil composition fluctuations (moisture), decreased coating integrity, and an aging CP system.

Table 6. West Tank Farm Rectifier Output (volt/amp)				
RECTIFIER	JULY 1994	JANUARY 1995	JUNE 1995	ADJUSTMENTS[3]
22	115/7.4	136/7.4	N/A	D-2 to max (D-5)
23	91.4/11.8	85.9/8.0	86.6/12	None
24	46.5/4.5	Not operational	54/4.5	B-2 to B-3
25	66.8/6	Not operational	67.6/8	None
26	40/5.2	40/5.2	39.3/5.2	None
27	69.6/2.9	Not accessible	142/3	B-5 to max (D-5)
34	21.5/0.5	31.4/0.6	31.2/0.8[1]	A-5 to B-2
35	11.5/3.7	Not operational	14.6/2.4	B-1 to B-2
37	8/3.7	10.2/3.6	10.2/3.8[2]	A-4 to A-5

(1) Rectifier tap settings changed to B-5 following the June 1995 surveys. Rectifier output increased to 40V, 1.2A.

(2) Rectifier tap settings changed to B-2 following the June 1995 surveys. Rectifier output increased to 15V, 6A.

(3) Adjustments made following the July 1994 survey.

The results of key test stations surveys are presented in Table 7. Results from earlier surveys in June 1994 and January 1995 are also provided.

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS

TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
RECTIFIER 22, LINES 202 AND 203 FROM PFP TO 241 TX				8/23/95 survey
18-2	SST-202	-0.75	-0.71	-0.77
	SST-203	-0.76	-0.69	-0.77
18-3	SST-202	-0.59	not tested	-0.58
	SST-203	-0.59	not tested	-0.58
18-9	SST-202	-0.9	-0.9	-1 .01
	SST-203	-0.9	-0.9	-1.01
18-12	8" San. Wat.	-0.34	not tested	-0.37
RECTIFIER 23, LINES 202 AND 203 FROM PFP TO 241 TX				8/33/95 survey
19-1	SST-202	-0.94	not tested	-0.87
	SST-203	-0.94	not tested	-0.87
20-1	SST-202	-0.85	-1.06	-0.75
	SST-203	-0.85	-1.06	-0.75
Note: Survey of Rectifier 23 subsystem will be completed with of rectifier 22 and 45 Survey by PFP				
RECTIFIER 24, 241-U TANK FARM, DIVERSION BOX TRANSFER LINES				
22-4	TEST STATION NONEXISTENT			
22-4A	TEST STATION NONEXISTENT			
22-5	DR-327	-1.63	RECTIFIER OFF	NOT TESTED

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS				
TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
Note: this test station is also affected by rectifier 35 resulting in high potentials	6" DR	-1.63		
	SL-101	-1.63		
	4" RW	-1.62		
	SL-100	-1.33		
	SN-216	-1.63		
22-6	6" DR	NO ACCESS	RECTIFIER OFF	NO ACCESS
	1" RW			
	2" CNDS			
	4" WASTE			
22-7	2" RW	-0.48	RECTIFIER OFF	NO ACCESS
	2"RW	-0.48		
RECTIFIER 25, TRANSFER LINE BETWEEN S AND U TANK FARMS				
23-1	DR-327	-1.22	RECTIFIER OFF	-1.24
	SN-216	-1.22		-1.24
	SL-100	-1.22		-1.24
	SL-101	-1.22		-1.24
23-2	DR-327	-0.97	RECTIFIER OFF	-1.07

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS				
TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
	SN-216	-0.97		-1.06
	SL-101	-0.97		-0.91
	4" SW	-0.79		-1.07
	14" RW	-0.96		-1.07
	SL-100	-0.97		-1.07
RECTIFIER 26, 242-S TO S-152 AND SY-102				
23-5	SN-283	-0.95	RECTIFIER OFF	-1.08
	SN-284	-0.95		-1.08
	DR-324	-0.95		-1.08
23-6	SN-283	-1.13	RECTIFIER OFF	-1.12
	SN-284	-1.12		-1.12
	SL-175	-1.15		-1.12
23-7	DR-300	-1.1	RECTIFIER OFF	-1.12
	SN-201	-1.14		-1.12
	SN-200	-1.15		-1.12
	SL-113	-1.15		-1.12
	SL-114	-1.13		-1.12

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS

TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
24-1	SL-176	-0.62	RECTIFIER OFF	-0.61
	SN-282	-0.62		-0.61
	SL-175	-0.61		-0.61
	SN-275	-0.61		-0.61
	SN-276	-0.61		-0.61
	SN-281	-0.61		-0.61
RECTIFIER 27, LINES TO/FROM 241-S CATCH TANK AND 244-S SALT WELL RECEIVER				
24-17	V-561	-0.66	NO ACCESS	-0.56
	V-562	-0.66		-0.55
24-18	V-456	-0.49	NO ACCESS	-0.51
	V-522	-0.49		-0.51
	V-560	-0.49		-0.51
24-19	241-S-304	-0.23	NO ACCESS	-0.22
RECTIFIER 34, TX-152 DIVERSION BOX				
25-1	V-387	-0.55	N/A	-0.36
	V-388	-0.55	N/A	-0.36
25-2	V-387	-0.55	N/A	-0.36
	V-388	-0.55	N/A	-0.35

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS				
TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
25-3	V-404	-0.72	-0.73	-0.4
	V-398	-0.72	-0.73	-0.38
25-4	V-404	-0.72	-0.74	-0.36
	V-398	-0.72	-0.74	-0.37
RECTIFIER 35, U-FARM TRANSFER LINES TO VALVE PITS AND 244-U				
22-3	6" DR	-0.77	RECTIFIER OFF	-0.6
22-10	SN-216	-0.38	RECTIFIER OFF	-0.37
22-17	4" WASTE	-0.69	RECTIFIER OFF	-0.65
	2" CNDS	-0.69		-0.65
	4" RW	-0.69		-0.65
22-18	SN-266	-0.97		-0.84
	SN-265	-0.97		-0.84
	SN-264	-0.97		--
	SN-216	-0.97		--
	3" SCH. 40	-0.97		--
	4"RW	-0.89		--
22-21	SL-101	-1.25	RECTIFIER OFF	-1.25
	SN-216	-1.25		-1.24

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS				
TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
	SN-208	-1.26		--
	SL-100	-1.24		--
22-23	SN-266	-0.45	RECTIFIER OFF	-0.53
	SN-265	-0.45		-0.53
	SN-264	-0.45		--
	1-1/2" FL	-0.45		--
	SL-106	-0.45		--
	SL-108	-0.45		--
RECTIFIER 37, TRANSFER LINES TO/FROM 244-TX				
21-4	SN-211	-0.72		-0.68
	SN-208	-0.72		-0.68
	SN-204	-0.72		--
	SN-200	-0.72		--
	2" PA	-0.72		--
21-5	SN-200	-0.66		-0.55
	SST-203	-0.67		-0.55
	SST-202	-0.66		--

Table 7. Pipe-to-Soil Potentials, "OFF" VDC, WEST TANK FARMS				
TEST STATION	STRUCTURE	JULY 1994	JANUARY 1995	JUNE 1995
	SN-204	-0.66		--
	SN-208	-0.66		--
	SN-211	-0.66		--
21-6	SST-203	-0.66		-0.61
	SST-202	-0.66		-0.61
	6" RW	-0.33		--
	CI WCW	-0.66		--
21-7	SN-211	-0.53		-0.56
	SST-203	-0.53		-0.57
	SST-202	-0.53		--
	SN-206	-0.53		--
	SN-249	-0.53		--
	SN-208	-0.53		--
21-10	V-406	-0.73		-0.75
	V-408	-0.73		--
	V-402	-0.73		--
	1-1/2" DR	-0.73		-0.76

DISCUSSION

Most of the CP systems were found operating as intended and only minor tap setting adjustments of some of the rectifiers were required after an evaluation of the survey data. Some rectifier adjustments were made at the time of the surveys in an effort to bring the rectifiers to the operating conditions recommended by the consultant following the 1994 baseline survey. The survey results are described below:

Rectifier 22

This rectifier was surveyed in conjunction with the PFP survey on August 23, 1995. The test stations associated with this rectifier exist within the PFP security fence. The polarized potentials on the lines designed for protection would meet the 100 millivolt shift criteria if the native potentials were more positive than -0.48 volts at test station 18-3. Field tests of native potentials would be required. The sanitary water line at test station 18-12 is not designed for protection and the more positive potential recorded on the line indicates the line is not receiving any current. No adjustments were made to the rectifier. The rectifier is operating at the maximum tap setting and no lines are being over-protected.

Rectifier 23

The amperage output of rectifier 23 fluctuated during 1995. The structure-to-soil potentials on SST-202 and SST-203 remained near or more negative than the -0.85 standard. No adjustments were made to the rectifier as the polarization potentials were adequate to provide corrosion protection. Part of this subsystem was surveyed with Rectifier 22 and 45 by PFP. Test station 19-1 is within the security buffer zone of PFP.

Rectifier 24

Testing this subsystem was not achieved this year due to nonexistent and/or not accessible test stations. This subsystem is in need of testing to evaluate its operation. Test stations 22-6 and 22-7 were not accessible during the survey. The test stations were under cover blocks. Test stations 22-4 and 22-4A located near the 241-U-151 and -152 Diversion Boxes were never installed. Furthermore, lines entering these diversion boxes were never bonded together and may be experiencing accelerated corrosion from stray currents.

The installation of test stations 22-4 and 22-4A and bonding the transfer lines was interrupted in 1993 due to funding. This work should be completed to properly operate the CP system for proper protection of transfer lines entering the diversion boxes.

Rectifier 25

The structure-to-soil potentials were found to be more negative than required. The rectifier output was adjusted from B-5 to B-3 to make the polarization potentials more positive.

The 4" SW line was found isolated and picking up stray currents. This line was bonded into the cathodic protection system to eliminate the possibility of stray current corrosion.

Rectifier 26

The structure-to-soil potentials were found adequate with the exception of the transfer lines to SY-102. Project W-430 installed cathodic protection in 241-SY Tank Farm in 01/96. The new system provides the additional current necessary for protection. Reducing the output from this rectifier was advised to make the potentials more positive. The tap settings were reduced to A-5 in 1995.

Rectifier 27

This rectifier provides partial protection of three pipes (V560, V561 and V562) which are routed from the 241-SY Tank Farm south to the 244-S Saltwell Receiver and the 241-S-151 Diversion Box. The rectifier tap settings were maximized in 1995. The rectifier output is providing over 100 millivolts of polarization to the lines near the receiver vessel. The rectifier output voltage was lowered during the W-430 OTP testing to 100 volts, and then increased to 120 volts. The 100 millivolt polarization shift was still met at the lower voltage.
The measurement taken on the 241-S-304 Catch Tank is for reference only. The tank is considered non-protected piping and almost no current is being collected at the riser of the tank.

Modifications to this subsystem would be required to elevate the potentials to the most conservative -0.85 volt criteria. This could possibly be achieved by installing more anodes near the pipes. The rectifier is rated at 18 amps and was only delivering 3 amps during the annual test.
Test stations should be installed on V-561 and -562 between 241-S salt well receiver and SY tank farm to allow for further potential characterizations.

Rectifier 34

This subsystem was determined to be operating with low current output during the survey. The tap settings were increased to B-5 after measuring the pipe-to-soil potentials. The transfer lines require native potential measurements to gauge the 100 millivolt shift criteria.

Rectifier 35

The tap settings of this rectifier were increased from the initial June 1994 settings. The output current and structure-to-soil potential decreased from the June 1994 survey. Rectifier adjustments were recommended to drive the potentials in the more negative direction. Tap settings were changed to B-3.

Rectifier 37

All the measured structure-to-soil potentials on the transfer system protected by this rectifier were found more positive than the -0.85 volt criteria. The rectifier was adjusted to the tap setting of B-2 at the time of the survey in an effort to make the potentials more negative.

Two cases of discontinuity were located during the surveys in West Tank Farm. The two lines were picking up stray current. The isolated structures were bonded to the system by joining one of the two test leads from the isolated structure to a test lead of a protected structure. Both test leads were located in the same test stations. The isolated lines bonded to the CP systems were as follows:

* RW in 241-U Tank Farm at test station 22-31
* 4" SW north of 242-S Evaporator at test station 23-2

2.5 PFP Facilities

The Plutonium Finishing Plant's (PFP) cathodic protection (CP) system associated with Rectifier 45 was surveyed per Engineering Task Plan, Engineering Task Plan, PFP Cathodic Protection System Maintenance (WHC-SD-WM-ETP-147). The PFP annual survey required coordination with Tank Farm Maintenance and Operations to install pulse generators on Rectifier 22, which is located just outside the security fence, and on Rectifiers 23 and 37, which are located near 241-TX Farm. These rectifier systems, along with Rectifier 45, may influence each other's operation inadvertently due to stray currents and influence the results of the survey.

The CP system provides corrosion protection, as required by WAC 173-303-640, to PFP's underground transfer lines which are located between the 241-Z and 236-Z buildings. The protected lines are:

2" LSW-M9 w/4" ENC-M9,
2" SPARE-M9 w/4" ENC-M9,
2" HSW-M9 w/4" ENC-M9, and
2" SPARE-M9 w/4" ENC-M9.

Other lines in the vicinity may or may not be intentionally protected by the CP system. These lines, where they exist, were also tested during the survey.

The WAC Code requires annual surveys to assure the underground piping are adequately protected. Besides the annual surveys, bimonthly (every other month) rectifier inspections are required to verify the system is energized and operating. According to the Engineering Task Plan, bimonthly rectifier inspections are performed and documented by PFP. With PFP maintenance support, the 1995 annual CP survey was performed and the acquired data evaluated. These tests were performed on August 23, 1995 by PFP Electrical Maintenance with support of TWRS M&CE.

A permanent pulse generator exists in series with rectifier 45 to cycle the rectifier output on and off. Pulse generators were installed on Tank Farm's Rectifier 22, 23, and 37. These rectifiers protect the transfer lines which traverse from PFP to the 244-TX Salt Well Receiver.

SURVEY RESULTS

Rectifier 45, a standard oil-filled rectifier operating at constant voltage, was visually inspected and found in good condition. The rectifier oil appeared clean, in good condition, and at the proper level. No oil leaks from the rectifier were found. The rectifier gasket was replaced due to tearing. The permanently installed pulse generator was not operating properly. The rectifier output did not pulse as designed. The pulse generator was found incorrectly wired to the rectifier. The PFP Electrical Maintenance corrected the wiring and the rectifier/pulse generator series circuit operated as designed. The operational characteristics of Rectifier 45 are provided below:

Rectifier 45

Make: Good-All Electric
Model: CSOYSA 50-12 GLMTZ
Serial #: 92C1418
Part #: 0084706
Rectifier Input: 120 volts (AC), 7.5 amps
Maximum Rectifier Output: 50 volts (DC), 12 amps
Taps (as found): C-1

	Panel Readings	Meter (Portable) Readings
Rectifier Output:	30 VDC	29.39 VDC
DC amps (as found):	5.25 amps	5.31 amps

Shunt: 15 amps @ 50 mVolts

The survey results are presented in Table 8. The tap settings were set at C-1. As required by Tank Farm Maintenance test procedure 6-TF-357, Rev. 0, Testing of Cathodic Protection System, continuity tests were performed between each pipe in each test station. At test stations 45-1, 45-2, and 45-3 the resistance between test leads was greater than the 10 ohm criteria. This showed that adequate continuity between the pipes does not exist as designed. This suggests that the jumper cables may not have been installed on the piping near the 241-Z Building (H-2-87513, Rev. 1). Continuity exists at the remaining test stations.

Polarization potentials measured at test stations 45-1, 45-2, and 45-3 did not meet the -0.85 voltage criteria. "ON" minus "OFF" potential differences showed no current being collected by the pipes at stations 45-1 and 45-2 and that a relatively small amount of current was collected by the pipes at 45-3. This showed that cathodic protection between 241-Z and 243-Z Building, near anode jumper box AJB R45-1, was not being provided. The anode header cable had been disconnected at the rectifier and the anode junction box (AJB R45-1). The header cable was disconnected because field tests had shown that the header cable, shorting out in this region, caused the rectifier to continually overload its circuit.

Adequate corrosion protection is provided at test stations 45-4 and 45-5. All other test stations exhibit potentials less than the -0.85 volt criteria. Test station 45-7 was found flooded and the piping test leads were moderately corroded.

To overcome the lack of continuity near 241-Z building, the buried piping may be bonded together by either of two methods. The piping may be excavated to attach jumpers. A second less costly method would be to bond the lines together attaching jumpers between the test leads within the test box. If excavation of the CP system is planned to troubleshoot and repair the shorting anode header cable between 241-Z and 243-Z buildings, the lines could be easily bonded together.

Increasing the rectifier output is required to increase the polarized potentials at test stations 45-6, -7, and -8. The rectifier tap settings were changed to C-4 to increase the rectifier output. Once the disconnected header cable is reinstalled, the CP system must be surveyed again to assure the additional load does not reduce the protective current on the part of the system that is currently operating.

Test station 45-7 should be drained of water and the test leads cleaned of corrosion product. The cause of flooding in test station 45-7 should be identified and mitigated. The test station should be monitored to assure flooding does not occur again.

Table 8. Pipe-to-Soil Potentials (VDC), PFP

Test Station	Buried Structure	Portable Ref.		Ref. Cell 1		Ref. Cell 2	
		On	Off	On	Off	On	Off
45-1	2" LSW	-0.420	-0.416	-0.435	-0.436	N/A	N/A
	LSW Spare	-0.421	-0.421	-0.437	-0.434	N/A	N/A
	2" HSW	-0.423	-0.420	N/A	N/A	N/A	N/A
	HSW Spare	-0.425	-0.426	N/A	N/A	N/A	N/A
45-2	2" LSW	-0.424	-0.420	-0.386	-0.387	-0.328	-0.331
	LSW Spare	-0.427	-0.427	-0.389	-0.388	-0.332	-0.332
	Unknown 1	-0.408	-0.405	N/A	N/A	N/A	N/A
	Unknown 2	-0.411	-0.410	N/A	N/A	N/A	N/A
	2" HSW	-0.423	-0.424	N/A	N/A	N/A	N/A
	HSW Spare	-0.423	-0.423	N/A	N/A	N/A	N/A
45-3	2" LSW	-0.385	-0.349	-0.522	-0.464	0.431	-0.396
	LSW Spare	-0.383	-0.348	-0.522	-0.460	-0.432	-0.400

Table 8. Pipe-to-Soil Potentials (VDC), PFP

Test Station	Buried Structure	Portable Ref.		Ref. Cell 1		Ref. Cell 2	
		On	Off	On	Off	On	Off
	2" HSW	-0.385	-0.347	N/A	N/A	N/A	N/A
	HSW Spare	-0.385	-0.349	N/A	N/A	N/A	N/A
	Unknown 1	N/A	-0.319	N/A	N/A	N/A	N/A
	Unknown 2	-0.370	-0.348	N/A	N/A	N/A	N/A
45-4	2" LSW	-2.437	-0.860	-1.250	-0.970	-1.492	-0.968
	LSW spare	-2.436	-0.860	-1.250	-0.970	-1.490	-0.968
45-5	2" LSW	-1.306	-0.870	-0.600	-0.555	N/A	N/A
	LSW Spare	-1.306	-0.872	-0.600	-0.556	N/A	N/A
45-6	2" LSW	-0.790	-0.609	-0.493	-0.455	-0.456	-0.427
	LSW Spare	-0.789	-0.606	-0.493	-0.454	-0.456	-0.432
45-7	2" LSW	-1.659	-0.801	-3.141	-0.660	-1.337	-0.708
	LSW Spare	-1.659	-0.798	-3.140	-0.667	-1.337	-0.705
48-8	2" LSW	-0.712	-0.588	-0.724	-0.613	-0.592	-0.532
	LSW Spare	-0.711	-0.590	-0.723	-0.615	-0.591	-0.530

2.6 222-S Laboratory

Cathodic protection was installed in 1995 under project W-041H, Environmental Hot Cell Expansion, and energized by ICF-Kaiser Engineers. As detailed in Drawing H-2-83281, Rev. 1, this CP system provides corrosion protection to underground transfer lines between the 222-S Bldg expansion and Tank 101. The protected lines are:

2" DR-1-M9 w/4" Enc-M9,
2" DR-2-M9 w/4" Enc-M9, and
all stainless steel HVAC piping in contact with earth.

This cathodic protection system consists of Rectifier R-44 and two test stations (T(44-4) and T(44-4A)). These test stations are located in a single test enclosure behind 222-S Bldg Expansion. Fifteen vertical anodes are installed in series via the anode loop cable to direct the protective currents onto the above referenced protected lines.

A second cathodic protection system was installed in 1996 to protect the new liquid waste drain lines from 222-S Laboratory to 219-S Building (Tank 101). This system was installed under Hanford Project W-087, Radioactive Liquid Waste Line Replacement. This system has been energized since 5/28/96 following the successful completion of the Acceptance Test Procedure W-087-ATP-001 Rev. 2. The lines under protection are:

2"WT-5701-M9,
2"WT-5702-M9,
2"WT-5703-M9, and
2"WT-5704-M9.

Following completion of Project W-041H, the CP system was surveyed per WAC 173-303-640 on April 7, 1995. Tests performed showed the cathodic protection system was operating at a pipe-to-soil potential <(-)1V versus a copper/copper sulfate reference electrode. The pipe-to-soil potential measurements were not made with the use of a pulse generator/waveform analyzer combination. Hence the resulting readings were not polarized potential readings and represented an additional IR voltage drop in the potential readings.

Following these preliminary tests, the rectifier was inspected and the CP system was surveyed on June 14, 1995 with the use of a pulse generator/waveform analyzer combination.

SURVEY RESULTS

The Rectifier 44 CP system was surveyed at Test Stations 44-4 and 44-4A. The other test stations depicted on Drawing H-2-83281, Rev. 1 (Test Stations 44-1 through 44-3) were not installed. The Anode Junction Box AJB 44-1 was located within the RCA zone near Tank 101 under the protective tarpaulin/berm. The tarpaulin is used for liquid containment during (storage tank)-to-(tank car) pumping operations.

Rectifier 44 was found operating and in good condition. The rectifier design is similar to all others at Hanford. The rectifier is an oil-cooled unit operating at constant voltage. The transformer oil appeared clean, in good condition, and at the proper level. Very small oil weeps were observed from welds near one bottom corner of the rectifier case.

The as-found characteristics of rectifier 44 are provided below:

Rectifier 44

Make: Good All Electric
Model: CSOYSA 60-12 GNTZ
Serial #: 92C1881
Part #: 0085167
AC Input: 120 volts
AC Current: 8.9 amps
Maximum Output: 60 volts (DC), 12 amps
Taps (as found): B-5

	Panel Readings	Meter (Portable) Readings
DC Potential (as found)	34	33.4
DC Amps (as found):	2.75	3

Shunt: 15 amps @ 50 mVolts

Pipe-to-soil potentials measured with the portable reference cell are used rather than those obtained with the permanent reference cell(s). The potentials obtained with the permanent reference cells are questionable. The difference in potentials between the portable and permanent reference cells was possibly due to the permanent reference cells located under the laboratory facility and/or the drier soil. Past experience indicates that data obtained with the permanent reference cells are questionable. This is clearly evident in the results presented in Table 9.

The initial pipe-to-soil potential measurements with the rectifier tap settings at B-5 are presented in Table 9. Not only are differences observed between the portable and permanent reference cells, but differences exist between the measured potentials of both permanent reference cells in Test Station 44-4.

Table 9. Pipe-to-Soil Potentials (VDC), 222-S at Tap Setting B-5							
Test Station	Buried Structure	Portable Reference		Reference Cell 1		Reference Cell 2	
		ON	OFF	ON	OFF	ON	OFF
44-4	16" duct north (1)	-2.652	-1.272	-1.038	-0.644	-1.578	-0.475
	16" duct south (1)	-2.651	-1.271	-1.038	-0.646	-1.578	-0.476
	16" duct south (2)	-2.652	-1.271	-1.038	-0.643	-1.578	-0.478
	16" duct north (2)	-2.653	-1.276	-1.038	-0.644	-1.577	-0.475
44-4A	DR-1 (1)	-2.621	-1.252	-0.510	-0.371	--	--
	DR-2 (1)	-2.621	-1.255	-0.509	-0.374	--	--
	DR-2 (2)	-2.620	-1.254	-0.510	-0.374	--	--
	DR-1 (2)	-2.620	-1.254	-0.510	-0.374	--	--

The "OFF" potentials measured using the portable reference cell were found to be greater (electronegatively) than the -0.85 volt criteria. The tap settings were reduced from B-5 to B-3 to bring the "OFF" potentials in line with the criteria. The structures were retested after adequate time allowing for system stabilization. The pipe-to-soil potential measurements at this reduced tap setting are presented in Table 10. The potentials measured utilizing the permanent reference cells were not obtained.

Table 10. Pipe-to-Soil Potentials (VDC), 222-S at Tap Setting B-3							
Test Station	Buried Structure	Portable Reference		Reference Cell 1		Reference Cell 2	
		ON	OFF	ON	OFF	ON	OFF
44-4	16" duct north (1)	-2.242	-1.195	--	--	--	--
	16" duct south (1)	-2.241	-1.195	--	--	--	--
	16" duct south (2)	-2.242	-1.195	--	--	--	--
	16" duct north (2)	-2.243	-1.196	--	--	--	--

Table 10. Pipe-to-Soil Potentials (VDC), 222-S at Tap Setting B-3							
Test Station	Buried Structure	Portable Reference		Reference Cell 1		Reference Cell 2	
		ON	OFF	ON	OFF	ON	OFF
44-4A	DR-1 (1)	-2.252	-1.205	--	--	--	--
	DR-2 (1)	-2.252	-1.202	--	--	--	--
	DR-2 (2)	-2.252	-1.200	--	--	--	--
	DR-1 (2)	-2.251	-1.203	--	--	--	--

As the resulting pipe-to-soil potential measurements continued to remain more negative than the -0.85 volt criteria, the tap settings were lowered to A-2 and the system allowed to stabilize. The rectifier output characteristics at tap setting A-2 were 0.625 Amps at 5 volts. The pipe-to-soil potential measurements are presented in Table 11. The potentials were found to be more positive than the NACE criteria, requiring an increase in the rectifier output.

Table 11. Pipe-to-Soil Potential (VDC), 222-S at Tap Setting A-2							
Test Station	Buried Structure	Portable Reference		Reference Cell 1		Reference Cell 2	
		ON	OFF	ON	OFF	ON	OFF
44-4	16" duct north (1)	-0.980	-0.679	--	--	--	--
	16" duct south (1)	-0.980	-0.677	--	--	--	--
	16" duct south (2)	-0.980	-0.677	--	--	--	--
	16" duct north (2)	-0.979	-0.675	--	--	--	--
44-4A	DR-1 (1)	-0.992	-0.686	--	--	--	--
	DR-2 (1)	-0.992	-0.684	--	--	--	--
	DR-2 (2)	-0.992	-0.682	--	--	--	--
	DR-1 (2)	-0.992	-0.686	--	--	--	--

Assuming an approximate linear relationship between the rectifier output and the pipe-to-soil "OFF" potentials at tap settings B-5 and A-2, a rectifier output of 14 volts was recommended. The tap settings were increased to A-4. The initial rectifier output at tap setting A-4 was 1.5 amps. The cathodic protection system was allowed to stabilize and was resurveyed at a later date.

The pulse generator was removed and the rectifier returned to normal operation. The system was allowed to stabilize for a few months and then reevaluated. On November 9, 1995 the pulse generator was reinstalled and the system retested during the bi-monthly inspection of the cathodic protection Rectifier 44.

The steady state rectifier tap setting (A-4) provided an electrical output of 12.8 Vdc at 0.99 amps. As anticipated, the output current decreased from the initial output of 1.5 amp. This decrease in current is due to polarization of impressed current anodes over time. The pipe-to-soil potentials were measured with a wave form analyzer, capturing the "ON" and the "OFF" potentials generated by the pulse generator/rectifier series combination. The measured values are presented in the Table 12.

Table 12. Pipe-to-Soil Potentials (VDC), 222-S at Tap Setting A-4

Test Station	Buried Structure	Portable Reference	
		ON	OFF
44-4	16" duct north (1)	-1.329	-0.845
	16" duct south (1)	-1.330	-0.845
	16" duct south (2)	-1.332	-0.845
	16" duct north (2)	-1.332	-0.847
	Reference North	0.727	0.389
	Reference South	0.570	0.511
44-4A	DR-1 (1)	-1.281	-0.810
	DR-2 (1)	-1.281	-0.810
	DR-2 (2)	-1.282	-0.812
	DR-1(2)	-1.282	-0.811
	Reference	0.965	0.548

The rectifier taps were subsequently adjusted to B-1 to increase the rectifier output. The rectifier was allowed to stabilize. On 12/12/95, the rectifier output was measured and found to be 19.92 Vdc at 1.62 amps. From the data obtained during the annual survey of Table 12, the rectifier will provide adequate corrosion protection. Using the previous linear correlation, the predicted pipe-to-soil "OFF" potentials will be more negative than -0.85 VDC when the rectifier output is at 19 volts.

3.0 ON-GOING DEVELOPMENT WORK AND TESTING REQUIREMENTS

1) Cathodic protection surveys are required on an annual basis per WAC-173-303-640. In addition, bi-monthly rectifier checks are required per the WAC codes. These required activities are incorporated into the maintenance production control process. A systematic mechanism to provide these data sheets to the cathodic protection cognizant engineering position in a timely manner is under development.

2) A thorough understanding of each metal structure in contact with the ground is necessary to properly evaluate the results of the CP surveys. The results have demonstrated more positive potentials than the most conservative criteria (-0.85 v) on many of the lines. The possible cause of these more positive potentials may be due to any of the following.

   - Proximity to other transfer lines
   - Proximity to waste tanks or other large metallic structures.
   - Inadequate anode distribution.
   - Low rectifier output.

3) To properly adjust, operate, and maintain the CP systems a thorough understanding of the system design in each tank farm along with an understanding of the buried structure configuration is required. Clear comprehensive drawings are required of each tank farm to accurately depict the installed CP system relative to the buried metallic structures, i.e., waste tanks, valve pits, other transfer lines, water lines, steam lines, etc. A CP system database that is currently under development will greatly facilitate the trouble shooting, adjustments, and modification of the CP systems.

4) Native potentials must be collected at the test stations which have pipes that are not polarizing more negatively than -0.85 VDC. Generally, the high majority of native potentials are more positive than -0.5 VDC and the 100 millivolt shift criteria would be realized at a polarized potential of -0.6 VDC.

5) Additional testing is required to see the extent of anodic polarization of the impressed current anodes. This data will provide valuable operational criteria for each CP system.

6) Baseline rectifier efficiency data should be collected to trend the operation of each rectifier.

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