Atlantic Richfield Hanford Company
Richland, Washington 99352

ARH-CD-975

FEASIBILITY OF APPLYING CATHODIC PROTECTION
TO DOUBLE-WALL WASTE STORAGE TANKS

E. L. Moore

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration nor any of their employees nor any of their contractors, subcontractors or their employees make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information disclosed, or represents that its use would not infringe privately owned rights.

PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION UNDER CONTRACT E (45-1) 2130

PRELIMINARY REPORT

THIS REPORT CONTAINS INFORMATION OF A PRELIMINARY NATURE. IT IS SUBJECT TO REVISION OR CORRECTION AND THEREFORE DOES NOT REPRESENT A FINAL REPORT. IT WAS PREPARED PRIMARILY FOR INTERNAL USE WITHIN THE ATLANTIC RICHFIELD HANFORD COMPANY. ANY EXPRESSED VIEWS AND OPINIONS ARE THOSE OF THE AUTHOR AND NOT NECESSARILY OF THE COMPANY.

NOTICE

THIS REPORT WAS PREPARED AS AN ACCOUNT OF WORK SPONSORED BY THE UNITED STATES GOVERNMENT. NEITHER THE UNITED STATES NOR THE UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, NOR ANY OF THEIR EMPLOYEES, NOR ANY OF THEIR CONTRACTORS, SUBCONTRACTORS OR THEIR EMPLOYEES, MAKES ANY WARRANTY, EXPRESS OR IMPLIED, OR ASSUMES ANY LEGAL LIABILITY OR RESPONSIBILITY FOR THE ACCURACY, COMPLETENESS OR USEFULNESS OR ANY INFORMATION, APPARATUS, PRODUCT OR PROCESS DISCLOSED, OR REPRESENTS THAT ITS USE WOULD NOT INFRINGE PRIVATELY OWNED RIGHTS.

MASTER

54-6000-085 (8-75)

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

REA

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

FEASIBILITY OF APPLYING CATHODIC PROTECTION
TO DOUBLE-WALL WASTE STORAGE TANKS

E. L. Moore

GEOLOGIC STORAGE ENGINEERING
ADVANCED WASTE ENGINEERING DEPARTMENT

June 1, 1977

Approved:

R. C. Roal, Manager, Development Engineering

Operated for the Energy Research and Development Administration
by Atlantic Richfield Hanford Company under Contract EY-76-C-06-2130

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	3
SUMMARY	4
PRINCIPLE OF CATHODIC PROTECTION	4
FEASIBILITY STUDY	5
CONCLUSIONS	9
RECOMMENDATIONS	9
REFERENCES	9
APPENDIX A	
APPENDIX B	

FEASIBILITY OF APPLYING CATHODIC PROTECTION TO DOUBLE-WALL WASTE STORAGE TANKS

INTRODUCTION

Three double-wall waste storage tanks comprising the 241-SY Tank Farm have been constructed as part of the nuclear waste management program at Hanford. These tanks will provide additional interim storage for terminal waste solutions generated from the current waste solidification program. Each tank structure consists of three concentric shells. The innermost shell (primary tank) constructed of carbon steel contains the waste solution and is given a post fabrication thermal stress relief to prevent the occurrence of caustic induced stress corrosion cracking (SCC). The outermost shell is constructed of reinforced concrete designed to sustain the earthloads. This concrete shell is lined with carbon steel to form the secondary tank designed to provide redundant containment should the primary tank ever fail.

During fabrication one of the primary tanks (designated 241-SY-103) developed distortions (bumps) in the bottom plate which exceeded the bottom flatness specification. The concern was that when filled with waste solution the bumps would flatten and thus high tensile stresses would be reintroduced in the previously stress relieved primary tank. These stresses could then possibly present conditions suitable for the occurrence of SCC with consequent loss of primary containment. A concerted technical analysis effort and testing program was initiated to determine the serviceability of the 241-SY-103 Tank. The results of the studies have been reported.⁽¹⁾

Several recommendations for future waste tank construction at Hanford were made in reference 1. Two of the recommendations are related to SCC and are quoted below:

1. "Consider application of an impressed current cathodic protection system to future double-wall tanks as an added protection against stress corrosion cracking if studies determine it is economically and technically feasible."
2. "Develop an Energy Research and Development Administration - Richland Operations Office program and fund a study to better define the susceptibility of various carbon steels to stress corrosion cracking when exposed to high caustic waste solutions."

This report deals with the study conducted to determine the feasibility of applying cathodic protection to double-wall tanks containing high caustic terminal waste solutions. Only the results of the study conducted

to fulfill the second recommendation cited above and which influenced the decision on whether or not to apply cathodic protection, are discussed in this report.

SUMMARY

A study was conducted to determine the feasibility of applying impressed current cathodic protection to double-wall storage tanks containing terminal waste solutions. Norton Corrosion Limited concluded that such a system could be designed for installation on the tanks. Under their direction, Battelle Northwest Laboratories, conducted a laboratory study to develop necessary data for design of the system. A separate study conducted by Battelle Columbus Laboratories indicated that, while terminal waste solutions by themselves do not promote stress corrosion cracking, cathodic protection may promote this type of corrosion under certain conditions. As a result of these findings, the recommendation was made not to install cathodic protection on the double-wall tanks containing terminal waste solutions.

PRINCIPLE OF CATHODIC PROTECTION

Today probably the most important and well-known application of cathodic protection is in connection with the thousands of miles of underground oil, gas and water pipelines. It is perhaps less well-known as a means to protect the inside surface of storage vessels containing corrosive solutions.

A discussion of the mechanism of cathodic protection can be found in many texts on the subject of corrosion control. A treatment of the subject by Uhlig is particularly good.⁽²⁾ Briefly stated, when the surface of a structure is corroding, whether it is the surface of the pipeline in contact with the soil or the surface of a storage vessel in contact with a corrosive liquid, direct current leaves the corroding surface (anode area) and finds its way to the noncorroding surface (cathodic area). Both surface areas can be in close proximity on the same metal surface. By applying a direct current from an external source so that the current flows from a suitably placed anode to the surface to be protected, that surface becomes completely cathodic and corrosion ceases.

Cathodic protection is used on structures to prevent general and pitting corrosion as well as stress corrosion cracking. It was mainly to prevent the latter that the feasibility of applying it to the double-wall storage tanks was studied.

FEASIBILITY STUDY

Two firms were funded by Atlantic Richfield Hanford Company (ARHCO) to conduct the feasibility study. Battelle Northwest (BNW) developed the laboratory data under the direction of a nationally recognized firm specializing in cathodic protection, Norton Corrosion Limited (NCL) of Woodinville, Washington. These data were to be used in both assessing the feasibility of applying cathodic protection and in designing a cathodic protection system for the double-wall waste tanks.

The resulting laboratory study conducted by BNW was documented and appears in Appendix A of this report.

For this study a typical simulated terminal waste solution was used by BNW to develop data to permit the design of an appropriate cathodic protection system for installation on double-wall storage tanks.

An initial review of the 241-SY Tank Farm was made by NCL to determine the adaptability of cathodic protection. Their conclusion was that a cathodic protection system could be designed for the double-wall tanks. The balance of their participation in the study is described in their letter report included in Appendix B of this report. Their contract was terminated after initial results of a study being funded by ARHCO at Battelle Columbus Laboratories (BCL) became available.

The BCL study was being conducted to determine the corrosivity of solutions produced from the evaporation of radioactive liquid wastes.⁽³⁾ It was not originally intended that the BCL study complement the ARHCO funded cathodic protection feasibility study. Their study was initiated to comply with the second recommendation cited in the introduction to this report. However, polarization measurements made by BCL produced data that indicate SCC of carbon steel may be accelerated rather than mitigated in typical terminal waste compositions under certain conditions as the result of the application of a cathodic current by a cathodic protection system.

The BCL study had two main objectives:

1. To characterize the corrosivity of synthetic nonradioactive terminal waste solutions to ASTM A516 Grade 65 carbon steel used in construction of the 241-SY Tank Farm.
2. To determine the severity of stress corrosion cracking of carbon steel in terminal waste solutions.

The first objective was accomplished experimentally using a potentiodynamic polarization technique and the second by using a constant strain rate procedure. The reader may refer to this BCL report for details of these

experimental procedures. A brief discussion of the procedures and results of the study follow to assist the reader to understand their importance to the cathodic protection feasibility study.

When a carbon steel specimen is immersed in a sodium hydroxide solution and the potential of the specimen is varied electronically in the positive direction from the open circuit corrosion potential while measuring the corrosion current, polarization curves are obtained as shown in Figure 1. (The polarization curves are reproduced from reference 3 and included here for ease of discussion.) An analysis of such curves can indicate potentials which promote general corrosion, passivity, pitting or SCC. There is a critical potential range for carbon steel in a sodium hydroxide solution that extends from approximately -0.95 to -1.03 V(SCE). It is within this narrow potential range that SCC can occur in a pure caustic solution. The intercept of the polarization curves with the vertical axis (Figure) is the potential (E_c) at which carbon steel would be freely corroding and is called the open circuit or free corrosion potential. If in some manner, such as the introduction of oxidizing impurities, this potential is shifted upward into the critical potential range and the steel is highly stressed, SCC can result. An obvious way of preventing this upward shift of the open circuit potential is to force it downward to more negative values well below the critical potential range and hold it there. This is what is accomplished by the application of impressed current cathodic protection.

Returning once more to Figure 1, for pure hydroxide solution an anodic peak is observed in the critical potential range and carbon steel in this solution is said to exhibit active-passive behavior and thus susceptibility to SCC. Further results of the BCL study showed that with the addition of nitrite ion to sodium hydroxide solution, the steel became spontaneously passive and no anodic peak was observed on the anodic leg of the polarization curve (See Figure 2). Also the open circuit potential (E_c) was shifted to a more positive value which was above the critical potential range for pure caustic. Constant strain rate test conducted at this potential did not result in SCC - which demonstrates the inhibiting affect of the presence of sufficient nitrite ion (at least 0.10M) in terminal waste solutions. In fact, no SCC was observed in all solutions tested with compositions lying within the range predicted for terminal waste solutions to be stored in double-wall storage tanks. Thus cathodic protection would be of no value and, as further testing showed, may even promote SCC in some waste solutions.

In studying the effect of nitrite, nitrate and aluminate on the corrosion of carbon steel by caustic solutions a current reversal or submerged anodic peak was observed in the cathodic region (potentials more negative than E_c) of the polarization curve of Figure 2. A constant strain rate test conducted at the maximum current on this anodic peak resulted in severe SCC. The implication here is obvious. By applying cathodic protection to maintain the potential at values more negative than the critical potential

FIGURE 1 POTENTIODYNAMIC POLARIZATION BEHAVIOR OF ASTM 516 STEEL IN SYNTHETIC WASTE SOLUTION B-7 (Taken from reference 3)

FIGURE 2 POTENTIODYNAMIC POLARIZATION BEHAVIOR OF ASTM 516
STEEL IN SYNTHETIC WASTE SOLUTION B-9 (Taken from reference 3)

range (-0.95 to -1.03 V(SCE)), the potential may unknowingly be shifted into a submerged anodic peak region and SCC could result in the presence of sufficiently high tensile stress in the primary tank.

As a result of these findings the decision was made not to proceed with design and installation of an impressed current cathodic protection system on the double-wall storage tanks containing terminal waste solutions.

CONCLUSIONS

The following conclusions were drawn from this feasibility study:

1. An impressed current cathodic protection system could be designed for installation on the double-wall waste storage tanks.
2. Under certain conditions the application of cathodic protection to double-wall storage tanks, containing terminal waste solutions, stress corrosion cracking may be promoted rather than be prevented.
3. No composition within this anticipated range of compositions for terminal waste solutions was found to promote stress corrosion cracking of ASTM A516 Grade 65 normalized carbon steel.

RECOMMENDATIONS

The following recommendations are made:

1. An impressed current cathodic protection system should not be installed on the double-wall storage tanks containing terminal waste solutions.
2. The study by Battelle Columbus Laboratories to determine the corrosivity of solutions from evaporation of radioactive liquid wastes should be extended to include an evaluation of ASTM A 537 Class 1 carbon steel to be used in construction of additional double-wall storage tanks at Hanford.

REFERENCES

1. ARH-LD-146 (unclassified), July 1, 1976, V. D. Schrag, "Technical Record of the 241-SY-103 Primary Tank Bottom Flatness Problem."
2. H. H. Uhlig, Corrosion and Corrosion Control, Second Edition. John Wiley and Sons, 1971.
3. ARH-C-18 (unclassified), May 4, 1977, J. H. Payer, et.al., Battelle Columbus Laboratories, "Corrosivity of Solutions From Evaluation of Radioactive Liquid Wastes."

APPENDIX A

Pacific Northwest Laboratories
Battelle Boulevard
Richland, Washington 99352
Telephone (509) 942-3828
Telex 32-6345

January 11, 1977

Mr. E. L. Moore
Research Engineering Division
ARHCO
271 T Building, 200 West Area

Dear Ernest,

Enclosed are three copies of our report entitled "Cathodic Protection of Underground High-Level Waste Tanks" which describes the work done to define an appropriate cathodic protection system for the subject tanks.

Unfortunately, recent polarization studies made at Battelle Columbus have produced data that indicate SCC may be accelerated rather than mitigated under certain conditions as a result of cathodic protection. Application of a C.P. system to Hanford waste tanks must of necessity await a thorough study of the system.

Sincerely,

R. F. Maness
Senior Research Scientist
Corrosion Research
and Engineering

Enclosures

CATHODIC PROTECTION OF UNDERGROUND HIGH-LEVEL WASTE TANKS

INTRODUCTION

Cathodic protection (C.P.) was considered as one means of limiting general corrosion and eliminating pitting attack and stress corrosion cracking (SCC) of the I.D. of underground high-level waste tanks at Hanford. Those tanks considered for C.P. were the double wall tanks which will be used to contain terminal liquor, i.e., the residual liquid phase remaining after salt cake formation. Some consideration was also given to the utilization of C.P. to mitigate corrosion of tanks containing salt cake. An experimental program was undertaken to obtain the data necessary for the design of an appropriate C.P. system. The data so obtained are the subject of this report.

EXPERIMENTAL PROGRAM

Materials

The composition of the terminal liquor used throughout this study is given in Table I.

Table I.

Composition of Terminal Liquor

<u>Material</u>	<u>Molarity</u>
NaOH	6.4
NaAlO ₂	3.4
NaNO ₃	3.3
NaNO ₂	3.9
Na ₂ CO ₃	0.1
Na ₃ PO ₄	0.01
Na ₂ SO ₄	0.05
Na ₂ SiO ₃	0.003
NaF	0.005
NaCl	0.1

The solids content of terminal liquor varies from about 85 vol. % at 25°C to about 5 vol. % at 100°C.

Unless otherwise noted, the corrosion specimens as well as specimens used to obtain electrochemical data were fabricated from mild steel ASTM A-201, grade B.

Conductivity Data

The conductivity or specific resistance of the sludge associated with terminal liquor was determined at 60°C as a function of aging time, 1 to 60 days. The specific resistance remained constant at 6 to 7 ohm-cm over the test period. The specific resistance of the supernatant liquid in equilibrium with the sludge at 60°C was 3.8 ohm-cm. This value decreased to 3.2 and 2.5 ohm-cm respectively as the temperature was increased to 70 and 80°C. Thus, the specific resistance of sludge appears to be about 1.7-fold higher than that of the equilibrium supernatant liquid. Some under-protection of metal in contact with sludge or over-protection of metal in contact with supernatant liquid would therefore occur in a normally designed C.P. system.

The specific resistance of simulated solidified waste (20% NaOH, 15% NaAlO₂, 1% NaCl, 10% NaNO₂, 15% Na₂CO₃·H₂O, 39% NaNO₃) was determined as a function of excess water content with the results given in Table II.

Table II.

<u>Specific Resistance of Simulated Solidified Waste</u>		
<u>Water Content, %</u>	<u>Temp. °C</u>	<u>Specific Resistance, ohm-cm</u>
0.0	25	>615,000
0.5	25	>615,000
1.0	25	11,200
2.0	25	570
5.0	25	310
10	25	80
15	25	45
15	40	35
15	50	25
15	60	20

It is doubtful that in-tank-solidification will produce a solid containing much less than about 10% water, thus C.P. of tanks containing this waste appears to be feasible from the standpoint of conductivity. Dry waste would not require cathodic protection.

Corrosion Rate vs Current Density

Mild steel coupons cathodically protected at current densities of 10, 7.5, and 5 ma/ft² were exposed to terminal liquor at 70°C for two months. Corrosion of all coupons was nil as determined by weight loss and visual observation. The coupons were then exposed for an additional two months at current densities of 4, 2 and 1 ma/ft². Corrosion rates as determined by weight loss were 0.1, 0.2, and 0.3 mils/year, respectively. No preferential attack occurred. Unprotected coupons corroded at a rate of about 0.5 mils/year with no preferential attack.

Cathodically protected mild steel specimens were also exposed to simulated solidified waste and examined after 2 1/2 months exposure.

These exposures were made to waste containing 15% water and held at 85°C; current densities were 10, 5, and 2.5 ma/ft². The specimens exposed to current densities of 2.5 and 5 ma/ft² corroded at rates of 1 to 2 mils/year as evidenced by weight loss. However, pitting attack was relatively severe (~5 mil penetration) in both cases. The specimens exposed at a current density of 10 ma/ft² evidenced no pitting attack and corroded at a rate of 0.8 mils/year as determined by weight loss. The simulated solidified waste contained, in addition to water, 20% NaOH, 39% NaNO₃, 15% NaAlO₂, 10% NaNO₂, 1% NaCl and 15% Na₂CO₃·H₂O.

Polarization Data

A potentiodynamic polarization curve was determined with mild steel in contact with terminal liquor at 72°C and is given in Figure 1. The solution was deaerated with nitrogen and the polished mild steel specimen was equilibrated with the solution for 24 hours prior to making the potential scan. The corrosion potential is seen to be about - 990 mv vs Ag:AgCl. Application of a cathodic current under the test conditions resulted in nearly linear polarization when evaluated on a semi-log plot. Anodic polarization produced an anodic peak and an extensive passive region. The corrosion rate calculated on the basis of the current density found in the passive region is about 50 - fold higher than that determined by weight loss, about 2 mils/month vs 0.5 mils/year. The rapid increase in current at potentials greater than about +0.2v(vs Ag:AgCl) is due to oxygen evolution.

The potential of mild steel specimens in contact with terminal liquor at 70-75°C was also determined as a function of current density and exposure time. Mild steel specimens covered with mill scale

and rust were used in these tests to better simulate the conditions found on the I.D. of underground waste tanks. The results, given in Figures 2, 3, and 4, indicate that equilibrium conditions are attained in about three hours. The rate of potential decay was determined on one of the above specimens after being polarized to a potential of about -930 mv vs Ag:AgCl. Following removal of the cathodic current, the initial potential increase was rapid and appeared to reach an equilibrium value of about -890 mv after three hours. No further change was noted after 48 hours.

Any number of surface conditions might be found on the I.D. of an underground tank in service, therefore the open circuit potential of mild steel specimens with a variety of surface conditions was determined as a function of exposure time to terminal liquor at 60°C. The results, given in Table III, indicate the various specimens attain an equilibrium value of about -600 mv vs Ag:AgCl regardless of the initial surface condition.

Table III.

<u>Potential of Mild Steel in Terminal Solution (60°C)</u>					
<u>Surface Condition of Mild Steel</u>	<u>Potential, mv (vs Ag:AgCl)</u>				
	<u>5 min</u>	<u>1 hr</u>	<u>72 hr</u>	<u>96 hr</u>	<u>120 hr</u>
1) Polished	-802	-791	-600	-600	-609
2) Freshly polished	-1014	-973	-705	-595	-550
3) Corroded. Three year contact with simulated Hanford high level wastes.	-520	-597	-593	-590	-587
4) Corroded. Two month contact with simul- ated Hanford high level wastes.	-480	-630	-608	-590	-613
5) As hot-rolled	-403	-420	-579	-582	-596

Anode Corrosion

Platinized Ti anodes would probably be used in any cathodic protection system designed to protect the I.D. of Hanford underground tanks. A laboratory-scale platinized Ti anode was obtained and used as an anode (20 amp/ft^2) in simulated terminal liquor at 70°C . On the basis of microscopic examination the anode showed no attack after 1000 exposure hours. Quantitative information on platinum corrosion when used as an anode in terminal liquor was determined by weight loss using small solid platinum anodes. The results, given in Table IV, indicate the life of a platinized Ti anode with a $50 \text{ }\mu\text{m}$ Pt coat, would be in excess of 100 years when used at a current density of 20 amp/ft^2 ($\sim 20 \text{ ma/cm}^2$).

Table IV.

Corrosion of Pt Anode in Terminal Liquor

Conditions: 1000-hour exposure at 70°C

<u>Current Density</u>	<u>Corrosion Rate</u>	
	<u>$\mu\text{m/year}$</u>	<u>$\mu\text{m/amp/hour}$</u>
3.5 ma/cm^2	.066	5.5×10^{-4}
20 ma/cm^2	.379	5.5×10^{-4}

Anode Arrangement

The number and arrangement of anodes to be used in a given C.P. system is an important design parameter. Equipment used to evaluate current density as a function of anode arrangement included a 2-ft. diameter flat bottomed mild steel tank filled to a depth of $7 \frac{1}{2}$ in. with $\text{NaOH-NaNO}_3\text{-NaNO}_2$ solution. The specific resistance of the solution at 25°C was 25 ohm-cm . The tank was constructed from $\frac{1}{8}$ in. mild steel plate (ASTM A-36) and was used in the as-fabricated condition,

i.e., mill scale and rust were not removed. A luggin capillary connected to a saturated calomel electrode (SCE) via a saturated KCl salt bridge was used to determine the potential existing at given positions within the tank. In a given determination anodes were positioned in a given arrangement and the current flow adjusted to a given average cathodic current density. Using the luggin probe, potential determinations were made at seventeen positions along a cross section of the tank. The determinations were repeated along a different cross section of the tank. Some of the results obtained are given in Figures 5 through 9. It is apparent that a large number of anodes are not required; four to six per 75 ft. diameter tank would probably be sufficient.

Continuing Work

No additional work is now contemplated. C.P. has historically been recognized as a safe means of mitigating corrosion; underprotection does some good and overprotection is of little concern unless amphoteric materials, e.g., lead alloys are involved. However, recent work by Berry⁽¹⁾ indicates that SCC of buried pipeline can occur in some cases as a result of the application of a cathodic current. The open circuit potential inside crevices was found, in some cases, to be more electro-positive than the pipeline surface by perhaps 100-200 mv. Application of C.P. was then sufficient only to decrease the potential within the crevice to the transition (SCC) potential. This information is somewhat disturbing but the conditions required to produce SCC were specific and application to Hanford underground waste tanks is not apparent.

(1) Berry, W.E., "SCC Laboratory Experiments," Fifth Symposium on Line Pipe Research, November 1974.

However, more extensive polarization studies at Battelle Columbus (J. H. Payer) with terminal liquor have indicated the presence of submerged cathodic peaks under certain conditions. The presence of these peaks can be interpreted to mean accelerated corrosion (SCC) can result from the application of a given cathodic current. Thus, application of a C.P. system to Hanford waste tanks must await a thorough study of the system.

FIGURE 1. POTENTIODYNAMIC POLARIZATION OF MILD STEEL IN TERMINAL LIQUOR

FIGURE 2. POTENTIAL OF CATHODICALLY PROTECTED MILD STEEL EXPOSED TO TERMINAL LIQUOR VS TIME

FIGURE 3. POTENTIAL OF CATHODICALLY PROTECTED MILD STEEL EXPOSED TO TERMINAL LIQUOR VS TIME

FIGURE 4. POTENTIAL OF CATHODICALLY PROTECTED MILD STEEL EXPOSED TO TERMINAL LIQUOR VS TIME

FIGURE 5. CURRENT DISTRIBUTION VS ANODE ARRANGEMENT

FIGURE 6. CURRENT DISTRIBUTION VS ANODE ARRANGEMENT

FIGURE 7. CURRENT DISTRIBUTION VS ANODE ARRANGEMENT

FIGURE 8. CURRENT DISTRIBUTION VS ANODE ARRANGEMENT

FIGURE 9. CURRENT DISTRIBUTION VS ANODE ARRANGEMENT

APPENDIX B

NORTON CORROSION LIMITED, Inc.

Seattle Office Phone: (206) 486-9126

22327 - 89th AVENUE, WOODINVILLE, WASH. 98072

July 30, 1976

Atlantic Richfield Hanford Co.
Federal Building
Richland, Washington 99352

Attention: E. L. Moore

Subject: Corrosion Engineering Services
Consultant Agreement CA-220
Prime Contract No. E (451)-2130
Final Report

Gentlemen:

Under the subject consulting agreement, NCL was retained to provide corrosion engineering services to:

1. Review ARHCO waste tank design for adaptability to application of cathodic protection.
2. Provide direction of ARHCO to conduct laboratory and field studies to determine design requirements for a cathodic protection system to protect the double-shell waste tanks from general and preferential corrosion.
3. Prepare final report of evaluation, which will include laboratory results and recommendations for the application of cathodic protection.

NCL proceeded with the initial review of the waste tank facilities for the adaptability of cathodic protection. This included both a physical on-site inspection tour, as well as a review of the construction drawings of the various tank designs. Our conclusions were that cathodic protection could be designed for the facilities. Several specific problems would have to be solved before the specific design could be made, but these problems appear to be solvable. Specifically, they concern the type of system, type of anode and reference electrode, amount of current required for cathodic protection and choice of insulating material to be used in this system.

Atlantic Richfield Hanford Co.

Page Two

July 30, 1976

An impressed current automatic potential controlled cathodic protection system was chosen as the type of system which would have the most possibility of success. Platinized titanium anodes suspended from the tank top with platinum reference electrodes were considered as the most reasonable choice for these items.

On April 27, 1976, NCL recommended to ARHCO a specific test procedure to determine the current density required for achieving cathodic protection and the maximum operating current density on the recommended anodes. These tests were to be performed by Battelle Northwest under a separate consulting agreement with ARHCO. At the same time, NCL was reviewing the market place for applicable insulating material that could be used on the reference electrodes. The three criteria used to evaluate the various materials were: (1) the maximum operating temperature of 250 degrees Fahrenheit, (2) the high alkaline level (pH 12-14) and (3) the radiation characteristics (1000 rads per hour). Numerous materials were under consideration and a final selection has not been made. Teflon and a fluoropolymer manufactured by Dupont called Tefzel appeared to have the most desirable characteristics. Teflon has been ruled out as not being suitable because of the radiation. Tefzel appears to be an acceptable material, but final approval of this material has not been made at this time.

On April 29, 1976, a tentative schedule for completion of this project was submitted to ARHCO. Data from the field tests being performed by Battelle were to be available to NCL by July 1, 1976. With this information, NCL was then to proceed with the preliminary design, utilizing the recommendations from the field tests and the materials selected.

On June 30, 1976, NCL was instructed to cease all work on Items 1 and 2 of Phase I of the subject contract. At that point in time, final decision as to insulating material, had not been made and field data from Battelle Northwest had not been received.

This report completes the responsibility of NCL on the subject contract. We regret that timing was such that the final decisions on materials, anodes and current requirements were not made and therefore, cannot become a part of this report.

NORTON CORROSION LIMITED

Atlantic Richfield Hanford Co.
Page Three
July 30, 1976

We appreciate the opportunity of working with ARHCO on this project. If there are further questions concerning our involvement, please contact us.

Very truly yours,

NORTON CORROSION LIMITED, INC.

Roy L. Cospers, P. E.- Vice Pres./Engineering

RLC:vb/E-5070