<p style="text-align: center; font-weight: bold; font-size: 1.2em;">S</p> <p style="font-size: 1.5em; font-weight: bold;">AUG 30 2000</p> <p style="font-size: 1.5em; font-weight: bold;">STA# 4</p>	<div style="border: 2px solid black; border-radius: 50%; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;"> <div style="border: 1px solid black; border-radius: 50%; width: 20px; height: 20px; display: flex; align-items: center; justify-content: center; margin: 0 auto;"> 4 </div> </div>	<p style="font-weight: bold; font-size: 1.2em;">ENGINEERING DATA TRANSMITTAL</p>	<p>Page 1 of 1</p> <p>1. EDT 629686</p>
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<p>2. To: (Receiving Organization)</p> <p>Distribution</p>	<p>3. From: (Originating Organization)</p> <p>Equipment Engineering</p>	<p>4. Related EDT No.:</p> <p>N/A</p>
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15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	RPP-6380		0	Design of Hanford Site's	N/A	1	1	
				Fourth-Generation Multi-				
				Function Corrosion				
				Monitoring System				

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)									
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature
		Design Authority				1	1	EA Fredenburg	<i>E. Fredenburg</i>
		Design Agent							
1	1	Cog. Eng. EC Norman	<i>E.C. Norman</i>	8/25/00					
1	1	Cog. Mgr. AH Friberg	<i>AH Friberg</i>	8/25/00					
		QA							
		Safety							
		Env.							

<p>18.</p> <p><i>E.C. Norman</i></p> <p>EC Norman</p> <p>Signature of EDT Originator</p> <p>Date: 8/25/00</p>	<p>19.</p> <p><i>[Signature]</i></p> <p>Authorized Representative for Receiving Organization</p> <p>Date: 8/25/00</p>	<p>20.</p> <p><i>AH Friberg</i></p> <p>AH Friberg</p> <p>Design Authority/Cognizant Manager</p> <p>Date: 8/25/00</p>	<p>21. DOE APPROVAL (if required)</p> <p>Ctrl No. _____</p> <p>☐ Approved</p> <p>☐ Approved w/comments</p> <p>☐ Disapproved w/comments</p>
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Design of Hanford Site's Fourth-Generation Multi-Function Corrosion Monitoring System

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Abstract: This document describes the design of the fourth-generation corrosion monitoring system scheduled to be installed in DST 241-AN-104 early in fiscal year 2001.
This report meets the requirements of TTP-RL09-WT-41 Milestone A.1-1.

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Design of Hanford Site's Fourth-Generation Multi-Function Corrosion Monitoring System

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Introduction

The Hanford Site has 177 underground waste tanks that store approximately 253 million liters of radioactive waste from 50 years of plutonium production [1]. Twenty-eight (28) tanks have a double shell and are constructed of welded ASTM A537-Class 1 (UNS K02400), ASTM A515-Grade 60 (UNS K02401), or ASTM A516-Grade 60 (UNS K02100) material. The inner tanks of the double-shell tanks (DSTs) were stress relieved following fabrication. One hundred and forty-nine (149) tanks have a single shell, also constructed of welded mild steel, but not stress relieved following fabrication. Tank waste is in liquid, solid, and sludge forms. Tanks also contain a vapor space above the solid and liquid waste regions. The composition of the waste varies from tank to tank but generally has a high pH (>12) and contains sodium nitrate, sodium hydroxide, sodium nitrite, and other radioactive constituents resulting from plutonium separation processes [1-4]. Leaks began to appear in the single-shell tanks shortly after the introduction of nitrate-based wastes in the 1950s. Leaks are now confirmed or suspected to be present in a significant number of single-shell tanks [1]. The probable modes of corrosion failures are reported as nitrate stress corrosion cracking (SCC) and pitting [2]. No leaks have been reported in Hanford DSTs.

Previous efforts to monitor internal corrosion of waste tank systems have included linear polarization resistance (LPR) and electrical resistance techniques [5-6]. These techniques are most effective for monitoring uniform corrosion, but are not well suited for detection of localized corrosion (pitting and SCC). The Savannah River Site investigated the characterization of electrochemical noise (EN) for monitoring waste tank corrosion in 1993, but the tests were not conclusive [7]. The Savannah River effort has recently been revived and a full-scale corrosion monitoring/chemistry monitoring system development effort is underway. System fabrication, cold-testing, and deployment are scheduled for FY 2001. Similarly, Oak Ridge National Laboratory has also launched an EN based corrosion monitoring system development effort. Lab testing, system design, fabrication, testing, and deployment are scheduled in FY 2001.

For many years, EN has been observed in industrial corrosion monitoring installations and laboratory experiments and the phenomenon is well established [8-19]. Typically, EN consists of low frequency (< 1 Hz) and small amplitude signals that are spontaneously generated by electrochemical reactions occurring at corroding or other surfaces [20]. Recent reports have reported that real-time EN based corrosion monitoring systems can be used to detect the onset of localized corrosion and measure uniform corrosion rates [14-26].

Due to the success of EN applications in other industries and a desire to improve Hanford's corrosion monitoring strategy, a two year laboratory study was started in 1995 to provide a technical basis for using EN in nuclear waste tanks at the Hanford Site [27]. Based on this study, a prototype system was constructed and deployed in DST 241-AZ-101 in August, 1996 [28]. Based on the operational experience with the prototype system, a decision was made to build a full scale system. The first-generation full-scale system was designed and installed into DST 241-AN-107 in September 1997 [29]. A second-generation full-scale system similar to the 241-AN-107 system was designed, fabricated and installed in 241-AN-102 in August 1998 [30]. A third-generation system was designed, fabricated and installed in 241-AN-105 in January 2000 [31, 32]. A fourth-generation full-scale system is scheduled for fabrication and deployment in

the 241-AN tank farm in early FY 2001. Each system has improved on previous system designs. This document describes the design of the fourth-generation corrosion monitoring system.

System Design

Like most EN based corrosion-monitoring systems, the fourth-generation system is designed to measure instantaneous fluctuations in corrosion current and potential between three nominally identical mild steel electrodes (a working, a counter, and a pseudo-reference electrode) immersed in the waste. The fluctuations in current and potential are caused by corrosion of the electrodes. It has been shown that each type of corrosion phenomenon presents a unique relationship between corrosion current and potential transients in the temporal data [8-29].

The fourth-generation system is similar to the third-generation multi-function instrument but adds a few new features. Drawings are available from HiLine Engineering and Fabrication, Inc. The following is a summary of the primary design features of the tank-intrusive portion of the system:

- The probe is fabricated from materials capable of providing at least five years of service.
- The maximum diameter of the probe fits through 10.2 cm (4.0 in.) diameter riser.
- The probe design facilitates decontamination by minimizing areas of liquid retention.
- All materials are capable of withstanding temperature ranges up to 100°C.
- All materials are capable of withstanding liquid phase pH ranges from 7 to 14.
- All materials are be capable of withstanding radiation levels up to 1000 R/hr.
- Probe design has passed site structural analysis for mixer pump operation [33].
- Probe design has passed site standard seismic analysis for non-safety class equipment [34].
- Conductor/feed-through connections shall be angled to withstand probe flexure.
- Gasketed surfaces use round-cut O-rings instead of square-cut O-rings for improved sealing.
- Probe incorporates eight channels of EN electrodes.
- Four channels of EN electrodes utilize 44 cm² C-rings.
- One electrode of each C-ring array is pre-cracked and strained prior to immersion.
- Four channels of EN electrodes utilize 25 cm² bullet shaped electrodes.
- EN electrodes are fabricated from ASTM A-537 CL 1 mild steel.
- Electrodes are electrically isolated from probe through the use of glass-lined feed throughs.
- Probe design contains an equally spaced array of 22 thermocouples.
- Probe design contains an adjustable verification thermocouple.
- Probe design contains a tank waste high level detector.
- Probe design contains three ports for pressure/gas sampling.
- Probe design contains strain gauges to monitor probe flexure if flexure occurs.
- Probe utilizes an adjustable collar to allow depth adjustment of probe during installation.
- Probe body serves as grounded shield to reduce unwanted interference in the data.
- Probe body is fitted with a built-in water lance to facilitate installation.

The following are the primary design features of the software/hardware used to collect data from the tank-intrusive portion of the probe:

- Current and voltage EN data is collected in an automated, user configurable fashion.
- Data is recorded at a rate of one measurement every other second.
- System simultaneously monitors eight channels of EN electrodes.
- System is capable of periodically conducting LPR scans.
- System is housed in a climate controlled enclosure adjacent to the riser containing the probe.
- Data acquisition computer is connected to Hanford Local Area Network to facilitate remote system operation from any internet connected computer.
- The operating software is compatible with Hanford site standard desktop PCs.
- All data is stored in ODBC and SQL compatible databases.

The tank-intrusive portion of the system is designed and manufactured by Hiline Engineering and Fabrication in Richland, Washington. The data collection hardware is a CIS400 system manufactured by Petroleum Research and Production, Ltd. The data collection software is an Amulet system manufactured by Corrosion & Condition Control, Ltd. The design of the complete system has been reviewed by the Hanford Site Flammable Gas Equipment Advisory Board and is bounded by report FGEAB-97-040, Rev. 2 [35].

Conclusions

A fourth-generation multi-function corrosion monitoring system has been designed for installation into a DST in the 241-AN farm at the Hanford Site in FY 2001. Improvements and upgrades from the third-generation system (installed in 241-AN-105) that have been incorporated into the fourth-generation system include:

- Addition of a built-in water lance to assist installation of probe into tanks with a hard crust layer at the surface of the waste.
- Improvement of the electrode mounting apparatus used to attach the corrosion monitoring electrodes to the stainless steel probe body (new design simplifies probe assembly/wiring).

These new features improve on the third-generation design and yield a system that is easier to fabricate and install, provides for a better understanding of the relationship between corrosion and other tank operating parameters, and optimizes the use of the riser that houses the probe in the tank.

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