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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

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		Design Authority R. S. Nicholson	<i>Robert M. Nicholson</i>	3/24/99	S5-05	1	1	J. L. Nelson	<i>J. L. Nelson</i>	3/24/99	R1-30
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18. <i>G. L. Edgemon</i> G. L. Edgemon Signature of EDT Originator 3/22/99 Date		19. <i>S. H. Rifaey</i> S. H. Rifaey Authorized Representative for Receiving Organization 3/21/99 Date		20. <i>Robert M. Nicholson</i> R. S. Nicholson Design Authority/ Cognizant Manager 3/21/99 Date		21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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Design of Multi-Function Hanford Tank Corrosion Monitoring System

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Abstract: Design description for Milestone B1 of FY 1999 TTP# RL0-8-WT-21.

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Introduction and Background

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 minor 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].

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 (SRS) investigated the characterization of electrochemical noise (EN) for monitoring waste tank corrosion in 1993, but the tests were not conclusive [7]. The SRS effort has recently been revived and additional testing is underway.

For many years, EN has been observed during corrosion and other electrochemical reactions, 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]. Laboratory studies and recent reports on field applications have reported that EN analysis is well suited for monitoring and identifying the onset of localized corrosion, and for measuring uniform corrosion rates [14-26]. A two year laboratory study was started at Hanford in 1995 to provide a technical basis for using EN in Hanford nuclear waste tanks [27]. Based on this study, a prototype system was constructed and deployed in DST 241-AZ-101 in August, 1996 [28]. Based on the successful demonstration of this prototype for more than a year, a 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 design, fabricated and installed in 241-AN-102 in August 1998 [30]. This document summarizes the design and operational requirements of the third-generation full-scale system scheduled for deployment into 241-AN-105 in fiscal year 1999 as required by Milestone Number B1 of TTP RL0-8-WT-21.

Like most EN based corrosion-monitoring systems, the 241-AN-105 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 241-AN-105 system is a multi-function instrument and contains several features not seen on previous Hanford systems. In addition to the eight channels of corrosion monitoring electrodes incorporated on previous probes, the new system is also fitted with an array of 22 thermocouples, a verification thermocouple, a tank waste high level detector, ports for pressure/gas sampling and a set of strain gauges to monitor the effects of tank operations on the downhole instrumentation. These features add a great deal of functionality to the probe, provide for a better understanding of the relationship between corrosion and other tank operating parameters, and optimize the use of the riser that houses the probe in the tank.

System Design

Details of the probe design are shown in the drawings attached at the end of this document. The following are the primary design features of the tank-intrusive portion of the 241-AN-105 corrosion monitoring 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 capable of withstanding radiation levels up to 1000 R/hr.
- Probe design has passed site structural analysis for mixer pump operation [31].
- Probe design has passed site standard seismic analysis for non-safety class equipment [32].
- Conductor/feed-through connections shall be angled to withstand probe flexure.
- Gasket seating surfaces utilize O-rings instead of a washer type gasket for improved seal.
- 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 heat treated to match tank.
- 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 one set of 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.

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.
- System uses wireless Ethernet links to send data to Hanford Local Area Network.
- System uses commercial remote access software to allow remote command and control.
- Above ground wiring uses driven shields to reduce external electrostatic noise in the data.
- MTL Model 755-AC shunt-diode type intrinsic safety barriers are used on all conductors.
- The operating software is compatible with site standard desktop PCs.
- All data is stored in ODBC and SQL compatible databases.

The tank-intrusive portion of the system is manufactured by Hiline Engineering and Fabrication in Richland, Washington. The data collection software/hardware system is an Amulet system manufactured by Corrosion & Condition Control, Ltd. The design of the corrosion monitoring system has been reviewed and approved by the Hanford Site Flammable Gas Equipment Advisory Board as documented in report FGEAB-97-040, Rev. 2 [33].

Conclusions

A multi-function corrosion monitoring system has been designed for installation into DST 241-AN-105 at the Hanford Site in fiscal year 1999. The 241-AN-105 system is the third-generation corrosion monitoring system described by TTP RL0-8-WT-21. Improvements and upgrades from the second-generation system (installed in 241-AN-102) that have been incorporated into the third-generation system include:

- Gasket seating surfaces utilize O-rings instead of a washer type gasket for improved seal.
- Probe design contains an equally spaced array of 22 thermocouples.
- Probe design contains an adjustable verification thermocouple.
- Probe design contains three ports for pressure/gas sampling.
- Probe design contains one set of strain gauges to monitor probe flexure if flexure occurs.
- Probe utilizes an adjustable collar to allow depth adjustment of probe during installation.
- System is capable of periodically conducting LPR scans.
- System is housed in a climate controlled enclosure adjacent to the riser containing the probe.
- System uses wireless Ethernet links to send data to Hanford Local Area Network.
- System uses commercial remote access software to allow remote command and control.
- Above ground wiring uses driven shields to reduce external electrostatic noise in the data.

These new design features have transformed what was primarily a second-generation corrosion monitoring system into a multi-function tank monitoring system that adds a great deal of functionality to the probe, 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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FOR PARTS LIST, GENERAL NOTES AND
REFERENCE DRAWINGS, SEE SH. NO. 1.

① ASSEMBLY, CORROSION PROBE TREE

SCALE: 1/4"

RESPONSIBLE PERSONNEL

DESIGNED BY: HL **HULNE ENGINEERING & FABRICATION INC.**
 2700 W. 10TH AVE., SUITE 200
 MINNEAPOLIS, MN 55412-4453
 TEL: 554-1144 FAX: 554-1144-5465

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9901-LMH-000A

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INSTRUMENT TREE
DETAIL DRAWING

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