1249981

[0064848H]

RPP-RPT-43725 , Rev. 0

SMALL DIAMETER GEOPHYSICAL LOGGING FOR C TANK FARM LEAK ASSESMENT OF TANK 241-C-105

H. A. Sydnor
Washington River Protection Solutions
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-08RV14800

RECEIVED
AUG 22 2018
EDMC

EDT/ECN: DRF UC:
Cost Center: Charge Code:
B&R Code: Total Pages: 12

Key Words: Geophysical, logging, C Farm, 241-C-105, Leak Assessment

Abstract: Pacific Northwest Geophysics (PNG) and Three Rivers Scientific provided small diameter logging in a probehole installed near the cascade overflow pipe line of single shell tank 241-C-105, in C Tank Farm. Logging was conducted in support of assessments to determine the source of the high gamma activity in drywell 30-05-07.

TRADEMARK DISCLAIMER. 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 or its contractors or subcontractors.

DATE:
STA: 4
HANFORD RELEASE
ID:
NOV 12 2009
2

Release Approval 11-12-2009 Date

Release Stamp

Approved For Public Release

RPP-RPT-43725
Revision 0

SMALL DIAMETER GEOPHYSICAL LOGGING FOR C TANK FARM LEAK ASSESMENT OF TANK 241-C-105

Russel Randall and Randall Price
Energy*Solutions* Federal Services, Inc.

Date
November, 2009

washington river protection solutions

Post Office Box 1500
Richland, Washington

Prepared for the U.S. Department of Energy
Office of River Protection

Approved for public release; distribution unlimited

SMALL DIAMETER GEOPHYSICAL LOGGING FOR C TANK FARM LEAK ASSESMENT OF TANK 241-C-105

by

Russel Randall, PhD and Randall Price

to

EnergySolutions Federal Services, Inc.
2345 Stevens Drive
Richland, Washington 99354

October 2009

Pacific Northwest Geophysics
4200 West 19th Avenue
Kennewick, Washington 99338

Three Rivers Scientific
3740 Grant Court
West Richland, Washington 99353

CONTENTS

1 PROBEHOLE SURVEYS 1
2 GAMMA DETECTOR CALIBRATIONS 3
3 REFERENCES 6

LIST OF FIGURES

Figure 1. NaI Calibration Certificate. 4
Figure 2. Green GM Calibration Certificate. 5

TERMS

Bgs	Below ground surface
Energy*Solutions*	Energy*Solutions* Federal Services, Inc.
GM	Geiger Mueller
OD	outside diameter
NaI	Sodium-Iodide
PNG	Pacific Northwest Geophysics

SMALL DIAMETER GEOPHYSICAL LOGGING FOR C TANK FARM LEAK ASSESMENT OF TANK 241-C-105

1 PROBEHOLE SURVEYS

Pacific Northwest Geophysics (PNG) and Three Rivers Scientific provided small diameter logging in a probehole installed near the cascade overflow pipe line of single shell tank 241-C-105, in C Tank Farm.

Logging surveys were conducted with the sodium-iodide (NaI) scintillation gross gamma detector and the moderate sensitivity Geiger-Mueller (GM) gross gamma detector. The logs were collected according to approved procedures (PNG 2009). Detector calibration certificates for the NaI and Green-GM detectors are presented in section 2 (Gamma Detector Calibrations).

Non-standard logging conditions were provided because radioactive contamination was encountered inside the probehole. The survey was acquired (as requested) from the top of the probehole (ground surface) down to the bottom. Logging was halted before the probe touched the bottom of the casing, which was at 11 meters (36 ft). The probehole was surveyed twice. The first survey was conducted with the Green GM detector positioned above the NaI detector. The second survey was conducted with the Green GM detector positioned at the bottom of the tool string, so that the gamma activity at the bottom of the probehole could be measured.

Due to concerns about contamination control, the log repeat measurement could only be acquired at the beginning of the survey. The computed results of the main and repeat intervals were reviewed and the results agree within the uncertainty of the measurement counting statistics. The repeat log data are presented with the main log plot.

The gross gamma survey data were dead-time corrected and the results were converted to the eCs-137 calibration units. Zero depth reference is at the ground surface. The survey results for the probehole are presented as a depth versus concentration plot.

The survey results for the NaI detector are shown as an **orange solid line** and the results for the Green GM detector are shown as a **green dotted line**. The plot scale for eCs-137 is logarithmic from 10 to 100,000,000 pCi/g (i.e. 10^1 to 10^8 or seven orders of magnitude).

The radiation levels within subsurface exceeded the NaI detection range of 68,000 pCi/g (eCs-137) at 7.16 meters bgs (23.5 ft). The radiation levels in the probehole continued to increase toward the bottom of the probehole and activity exceeded the Green GM detection range of 43,000,000 pCi/g of eCs-137 at 10.7 meters bgs (35 ft). The dead-time limit for measuring gamma radiation activity is 80% for both the NaI and Green GM detectors.

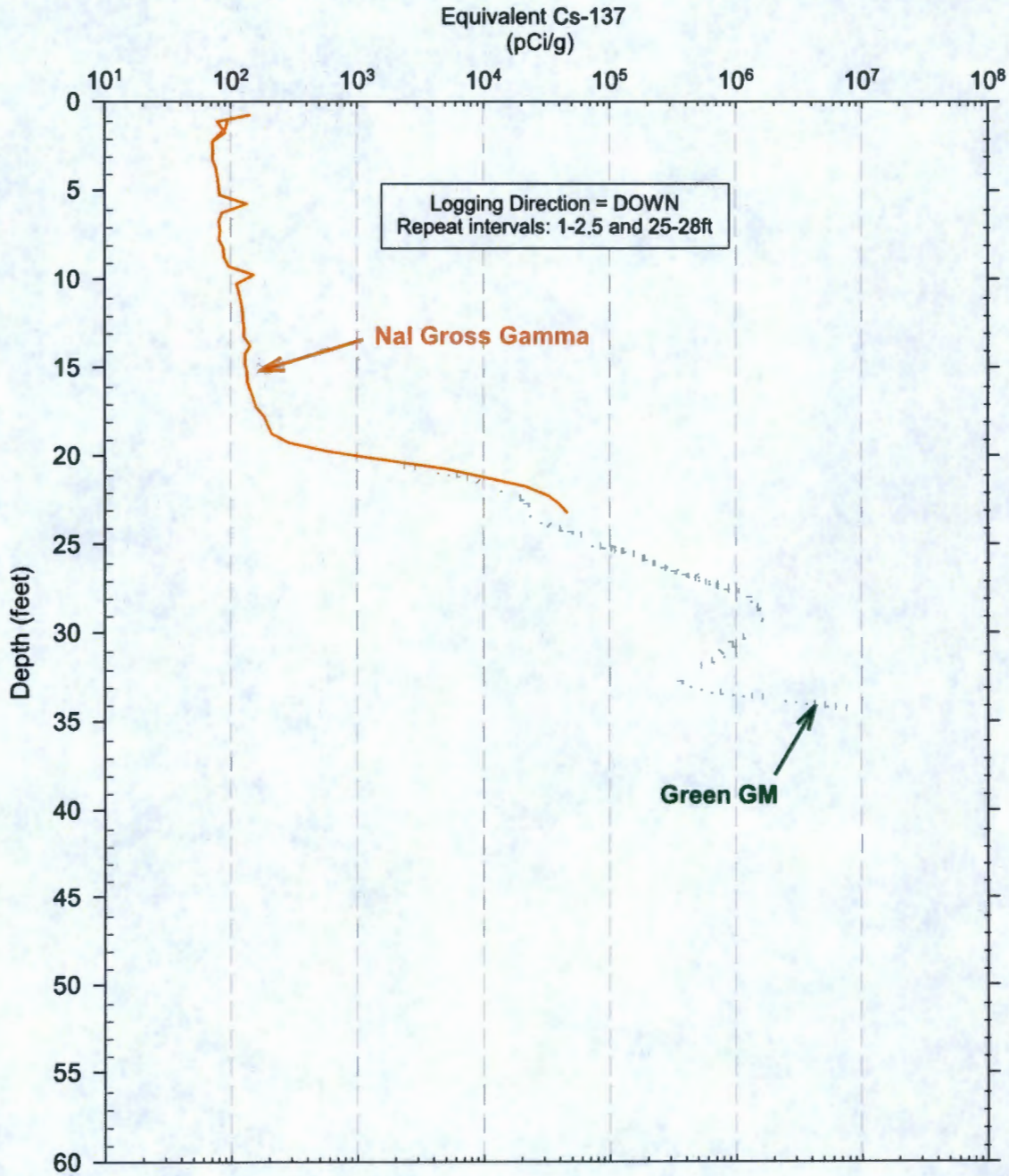
The log survey results for probehole C7469 are shown in the following plot.

Small Diameter - Gamma Survey

Energy Solutions & Pacific Northwest Geophysics

Project: C Tank Farm Push
Probehole: C7469

Log Date: October 2009
Depth Ref: Ground Level



2 GAMMA DETECTOR CALIBRATIONS

The gross gamma detectors were calibrated for both Eq ^{226}Ra and Eq ^{137}Cs. Eq ^{226}Ra is a measurement standard in the geophysical logging industry and is appropriate for gross gamma detectors to establish the activity levels of the naturally occurring radionuclides (KUT). The calibration for Eq ^{137}Cs assumes that all of the gammas are due to the presence of ^{137}Cs. The gamma activity encountered in this probehole exceeded the levels of the naturally occurring radionuclides, consequently the plot shows only Eq ^{137}Cs

The calibration for the NaI detector is discussed first, followed by the Green GM calibration.

The gross gamma scintillation detector uses a NaI crystal. The NaI crystal (1 in. long) is hydroscopic and is enclosed in a hermetically sealed can (1 in. diameter) to maintain its integrity.

The NaI gamma surveys were logged at 2 ft/minute. A spectrum of 256 channels was collected each 0.5 ft from the top of the probehole to the bottom. Detector count rates were dead-time corrected and the gamma survey data was processed as gross gamma response to determine the concentration of eRa-226 in pCi/g.

The dead time correction is a nonparalysable relationship (Knoll, 1979) and is described by the following equation:

$$C_t = \frac{C_{obs}}{1 - \varepsilon \cdot C_{obs}}$$

where C_t is the true or dead time corrected count rate in c/s, C_{obs} is the observed count rate in c/s, and ε is the dead time factor of 8.92μs. The dead-time factor was determined when the detector was calibrated for eCs-137 in the Hanford vadose well 299-W10-72.

The NaI gross gamma detector was also calibrated for eCs-137 (pCi/g). Calibration for eCs-137 was performed in Hanford vadose well 299-W10-72 (Cs-137 calibration standard). The Cs-137 in the well is stable, except for the 30 year half-life decay of the radioisotope. Also, distribution of Cs-137 ranges from less than 1 pCi/g to 40,000 pCi/g along the well path (depth). The concentrations of Cs-137 were established by two HPGe detectors (70% and High Rate tools, operated by Stoller Corp). Casing in the well is 0.288 in. thick. In order to duplicate the 0.38 in. casing of the small diameter probeholes a section of steel tubing 0.095 in. thick was installed over the detector for calibration. The conversion factor from detector count rate (cps) to eCs-137 is 0.384 (pCi/g per cps) for casing thickness of 0.38 in. See Figure 2 for the NaI calibration certificate.

The Green GM detector has lower sensitivity than the NaI detector and is designed to measure high gamma ray flux. The Green GM detector count rates were dead-time corrected (as described above for the NaI detector).and the gamma survey data was processed to determine the concentration of eCs-137 in pCi/g. The dead-time factor for the Green GM detector is 160μs. The Green GM calibration certificate is shown in Figure 3.

Figure 1. NaI Calibration Certificate.

Certificate of Calibration
SD.NaI.1
March 17, 2009

Data were taken at the Hanford KUT models on March 17, 2009. SD.NaI.1 is the designated Scintillator tool. Two models were used for the gross gamma calibration (SBU and SBL). Ten spectra were recorded for each model in order to perform statistical analysis. The observed deviations were seen to be near the theoretically predicted variation, refer to the files compressed: StatisticsNaI.xls for this analysis.

The instrument was covered with 0.38 inch wall-thickness probe-tubing.

The coefficient analysis is determined by the algorithm described in the document WHC-SD-EN-TI-293, Rev. 0. The gross gamma calibration for equivalent ^{226}Ra in pCi/g is a regression function and is generally defined by:

$$Ra = a*GR + b$$

Where Ra is the Eq. ^{226}Ra in pCi/g, and GR is the observed gross gamma count rate (c/s), dead time corrected. The coefficients of a & b are the fit coefficients. A more physical relationship constrains the intercept (b) to a zero value. This computation yields improved response extrapolated to low concentrations of K, U, and Th (clean zones). The coefficients were determined to be:

$$a = .1078 \quad Eq.^{226}Ra\ pCi/g\ /\ (c/s)$$
$$b \equiv 0$$

The calibration for eCs-137 in pCi/g for the SD.NaI.1 instrument is described in RPP-RPT-27605, *Gamma Surveys of Single Shell Tank Laterals for A and SX Tank Farm* (Randall and Price 2006). The gross gamma calibration for equivalent ^{137}Cs in pCi/g is a regression function and is generally defined by:

$$Cs = \alpha*GR$$

Where Cs is the eCs-137 in pCi/g, and GR is the observed gross gamma count rate (c/s), dead time corrected. The coefficient α is the fit coefficient.

There is a ratio of eRa-226 calibration coefficient to the eCs-137 calibration coefficient for each instrument. The ratio between the two coefficients in Randall and Price (2006) is 2.27. Thus a factor of 2.27 times the eRa-226 calibration will yield the eCs-137 calibration coefficient. Thus: α=0.245 eCs-137 (pCi/g)/(c/s)

Digital files condensed as Cal_SDGR-NaI_2009-v0.zip. This compressed file contains:

- Calibration raw data
- Spreadsheet data formatting

The undersigned certifies that the data archived in the file "Cal_SDGR-NaI_2009-v0.zip" were collected and evaluated in accordance with procedures WHC-SD-EN-TI-293, "Procedures for Calibrating Scintillation Gamma-Ray Well Logging Tools Using Hanford Formation Models" and that the above stated calibration coefficients are correct and applicable for the tool SD.NaI.1 effective March 21, 2009.

Signature:
/s/ Russel Randall, PhD Date: March 25, 2009
Three Rivers Scientific

Figure 2. Green GM Calibration Certificate.

Certificate of Calibration
SD.Green.GM
March 17, 2009

Data were taken at the Hanford KUT models on March 17, 2009. SD.Green.GM is the designated Green GM tool. One model was used for the gross gamma calibration (SBH). Ten spectra were recorded in order to perform statistical analysis. The observed deviations were seen to be near the theoretically predicted variation, refer to the files compressed: "StatisticsGGM.xls" for this analysis.

The instrument was covered with 0.38 inch wall-thickness probe-tubing.

The coefficient analysis is determined by the algorithm described in the document WHC-SD-EN-TI-293, Rev. 0. The gross gamma calibration for equivalent ^{226}Ra in pCi/g is a regression function and is generally defined by:

$$Ra = a*GR + b$$

Where Ra is the Eq. ^{226}Ra in pCi/g, and GR is the observed gross gamma count rate (c/s), dead time corrected. The coefficients of a & b are the fit coefficients. A more physical relationship constrains the intercept (b) to a zero value. This computation yields improved response extrapolated to low concentrations of K, U, and Th (clean zones). The coefficients were determined to be:

$$a = 363.9 \quad Eq.^{226}Ra\ pCi/g\ /\ (c/s)$$
$$b \equiv 0$$

The calibration for eCs-137 in pCi/g for the SD.Green.GM instrument is described in RPP-RPT-27605, *Gamma Surveys of Single Shell Tank Laterals for A and SX Tank Farm* (Randall and Price 2006). The gross gamma calibration for equivalent ^{137}Cs in pCi/g is a regression function and is generally defined by:

$$Cs = \alpha*GR$$

Where Cs is the eCs-137 in pCi/g, and GR is the observed gross gamma count rate (c/s), dead time corrected. The coefficient α is the fit coefficient.

There is a ratio of eRa-226 calibration coefficient to the eCs-137 calibration coefficient for each instrument. The ratio between the two coefficients is 4.81 (*Small Diameter Geophysical Logging In the 241-U Tank Farm,* Randall and Price 2008). Thus a factor of 4.81 times the eRa-226 calibration will yield the eCs-137 calibration coefficient and α=1746 eCs-137 (pCi/g)/(c/s)

Digital files condensed as Cal_SDGR-GrGM_2009-v0.zip. This compressed file contains:

- Calibration raw data
- Spreadsheet data formatting

The undersigned certifies that the data archived in the file "Cal_SDGR-GrGM_2009-v0.zip" were collected and evaluated in accordance with procedures WHC-SD-EN-TI-293, "Procedures for Calibrating Scintillation Gamma-Ray Well Logging Tools Using Hanford Formation Models" and that the above stated calibration coefficients are correct and applicable for the tool SD.Green.GM effective March 17, 2009.

Signature:
/s/ Russel Randall, PhD Date: March 25, 2009
Three Rivers Scientific

3 REFERENCES

Meisner, James and Russel Randall, 1995, *Vadose Zone Moisture Measurement Through Steel Casing Evaluation*, WHC-SD-EN-TI-304, Rev.0, Westinghouse Hanford Company, Richland, Washington.

Meisner, James, Randall Price, and Russel Randall, 1996, *Radionuclide Logging System In Situ Vadose Zone Moisture Measurement Calibration*, WHC-SD-EN-TI-306, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

PNG, 2009, *Procedures: Calibration, Logging, Quality Assurance and Data Management*, Pacific Northwest Geophysics, Kennewick, Washington.

R. Randall and D. Stromswold, 1995, "Procedures for Calibrating Scintillation Gamma-Ray Well Logging Tools Using Hanford Formation Models", WHC-SD-EN-TI-293, Rev. 0, Westinghouse Hanford Company, Richland, Washington.