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Test Plan for Measuring Ventilation Rates and Combustible Gas Levels in TWRS Active Catch Tanks

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TEST PLAN FOR MEASURING VENTILATION RATES AND COMBUSTIBLE GAS LEVELS IN TWRS ACTIVE CATCH TANKS

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Lockheed Martin Hanford Corporation

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CGM	combustible gas monitor
CPO	Characterization Project Operations
DB	diversion box
gal	gallon
LFL	lower flammability limit
OVM	organic vapor monitor
ppm	parts per million
%	percent
psig	pounds per square inch gauge
RQL	required quantitation limits
SAS	Special Analytical Support
SOP	standard operating procedure
TWRS	Tank Waste Remediation System
USQ	unreviewed safety question
WSCF	Waste Sampling and Characterization Facility

TEST PLAN FOR MEASURING VENTILATION RATES AND COMBUSTIBLE GAS LEVELS IN TWRS ACTIVE CATCH TANKS

1.0 PURPOSE AND SCOPE

The purpose of this test is to provide an initial screening of combustible gas concentrations in catch tanks that currently are operated by Tank Waste Remediation System (TWRS). The data will be used to determine whether or not additional data will be needed for closure of the flammable gas unreviewed safety question for these facilities.

This test will involve field measurements of ammonia, organic vapor, and total combustible gas levels in the headspace of the catch tanks. If combustible gas level in a tank exceeds an established threshold, gas samples will be collected in SUMMA[1] canisters for more extensive laboratory analysis. In addition, ventilation rates of some catch tanks will be measured to evaluate removal of flammable gas by air flow through the tanks.

2.0 BACKGROUND

In general, TWRS catch tanks were designed to collect leaks, spills, condensation, and drainage that might occur during operation of tank farm diversion boxes (DBs), valve pits, and pipeline encasement. Volume and constituents of the material in these tanks vary depending on the operations of the Tank Farm facilities. Most of these tanks are expected to contain small amounts of organic chemicals and low levels of radioactivity. Thus, flammable gases could be generated and accumulated in these tanks; however, the levels are expected to be very low. A list of the TWRS active catch tanks is shown in Table 2-1. Tank capacity, material of construction, and ventilation type (active or passive) are also provided.

Table 2-1. TWRS Catch Tanks (2 Sheets)

Item No.	Tank ID No.	Historical Usage	Nominal Capacity (gal)	Construction Material	Actively Ventilated?
1	241-A-302A	Drainage from DB 241-A-151	8,400 gal	Carbon steel	No
2	241-A-350	Drainage from A Farm	800 gal	Stainless steel	No
3	241-A-417	Drainage from 241-AY/AZ vent	44,000 gal	Concrete vault with carbon steel liner	No

[1] SUMMA is a trademark of Moletrics, Inc., Cleveland, Ohio.

Table 2-1. TWRS Catch Tanks (2 Sheets)

Item No.	Tank ID No.	Historical Usage	Nominal Capacity (gal)	Construction Material	Actively Ventilated?
4	241-AX-152	Drainage from AX-152 diversion station, DB 241-AX-155, AY-501, and 702-A seal pot	11,000 gal	Concrete vault with steel liner	Yes (indirectly from 702-AZ system)
5	241-AZ-151	Drainage from DB 241-AZ-152, AZ vent. Loop seals, leak detection pits, 801-AZ Instrumentation Building and precipitation/runoff	12,000 gal	Concrete vault with carbon steel liner	Yes (indirectly from 702-AZ system)
6	241-AZ-154	Drainage from AZ-101 and AZ-102 steam coils and precipitation/runoff	900 gal	Concrete vault with carbon steel liner	Yes (indirectly from 702-AZ system)
7	241-ER-311	Drainage from DBs 151-ER and 152-ER.	18,000 gal	Carbon steel	No
8	204-AR-TK-1	Drainage from the 204-AR Waste Unloading Facility unloading canyon.	1,500 gal	Stainless steel	Yes
9	241-S-304	Drainage from DB 241-S-151 and precipitation/runoff	6,000 gal	Carbon steel	No
10	241-TX-302C	Drainage from DB 241-TX-154 and precipitation/runoff	18,000 gal	Carbon steel	No
11	241-U-301B	Drainage from DBs 241-U-151, 241-U-152, 241-U-153, 241-U-252	36,000 gal	Concrete (unlined)	No
12	241-UX-302A	Drainage from DB 241-UX-154, 291-U stack, and precipitation/runoff	18,000 gal	Carbon steel	No
13	241-EW-151	Drainage from the former cross-site transfer vent station	800 gal	Carbon steel	No

3.0 OVERALL DESCRIPTION OF TEST

The baseline flammable gas content of each catch tank and the ventilation rates in two of the tanks will be measured. Gas levels will be measured in the field using portable or hand-held gas meters. Ventilation rates will be determined using the tracer gas injection method. These methods have been used successfully for waste tanks and double-container receiver tanks (Bauer 1998 and Bauer and Hedengren 1999). The gas level and ventilation rate measurement methods are specified in Table 3-1.

Table 3-1. Data Needs and Associated Measurement Methods

Data Needs	Measurement Methods
Combustible gas level	Combustible Gas Monitor (CGM)
Ammonia	Calorimetric (Draeger) Tubes
Organic vapor	Organic Vapor Monitor
Ventilation Rate	Tracer gas (Helium) injection

Flammable gas levels in the headspace of each catch tank will be measured. Prior to taking the measurements, the sampling system will be purged to assure that the sample system tubing is filled only with headspace gas. If the combustible gas level in a tank as measured by the CGM exceeds 25% of the lower flammability limit (LFL), three SUMMA™ canister samples will be collected for vapor gas characterization. These SUMMA™ samples would be analyzed for parameters listed in Table 3-2.

Table 3-2. Analytes of Interest if Combustible Gas Level Exceeds 25% of the Lower Flammability Limit

Carbon Monoxide Carbon Dioxide Hydrogen	Oxygen Nitrous Oxide Ammonia Organic Compounds (See Table 6.1)

The ventilation rates in the TWRS active catch tanks are not known and are expected to vary. Some tanks are passively ventilated; others are connected to an active ventilation system (702-AZ). The passively ventilated tanks either have breather filters or are connected to other systems that have air filters. Two tanks, 241-AX-152 and 241-A-417 (representing actively and passively ventilated tanks, respectively), have been selected for measurement to provide a preliminary indication of flammable gas removal rate due to air flow through the tanks.

Helium will be injected into the headspace of a designated tank through an assigned injection point as specified by the sampling cognizant engineer. The sampling cognizant engineer will specify the required volume of helium based on measured decrease in pressure of the gas supply. Two SUMMA™ samples will be collected after allowing the helium to disperse evenly throughout the tank headspace. One additional set of two SUMMA™ samples will be collected at a time interval to be specified by the sampling cognizant engineer. These SUMMA™ samples will be analyzed for helium concentration only. Ventilation rate in the tank will be calculated based on the measured decay in helium concentration between these points in time. The calculation method is derived and described in Appendix A.

Note that the tests described in this plan will provide screening data only. A comprehensive evaluation of potential variables (i.e., factors that could affect combustible gas generation or retention in a catch tank), such as volume, composition, and temperature of the waste and atmospheric conditions, etc., are outside the scope of this effort. However, these data will be recorded if available.

4.0 EXPECTED RESULTS

For each catch tank, combustible gas level (in %LFL), ammonia concentration (in parts per million [ppm]), and organic vapor level (in ppm) will be measured and reported. The levels of these gases and vapors in the catch tanks are expected to be very low.

Tank 241-AX-152 headspace is indirectly connected to the 702-AZ ventilation system and, thus, is considered an actively ventilated tank. This tank is expected to have a much higher ventilation rate than that of the passively ventilated tank 241-A-417.

5.0 TEST EQUIPMENT AND MATERIAL

Test equipment needed for each catch tank include:

- Combustible Gas Meter (CGM) for measuring combustible gas level,
- Organic Vapor Monitor (OVM) for measuring organic vapor concentration,
- Calorimetric (Draeger) tubes for measuring ammonia concentration, and
- Three SUMMA™ canisters (with the necessary tritium traps and canister particulate air filters) to collect gas samples in the event the combustible gas level in a tank exceeds the established threshold.

In addition, tracer gas injections for tanks 241-AX-152 and 241-A-417 will require the following equipment:

- Tracer gas injection and sampling systems as shown in Figures 1 and 2, respectively,
- A supply of bottled helium gas,
- SUMMA™ canisters (with canister particulate air filters),
- A tritium trap for each SUMMA™ canister and canister particulate air filters for radiation screening, and
- Temperature gauges to measure ambient and helium gas bottle temperatures.

Spare equipment for contingency will be available as required by standard operating procedures (SOPs) for the instruments or as determined by the sampling cognizant engineer

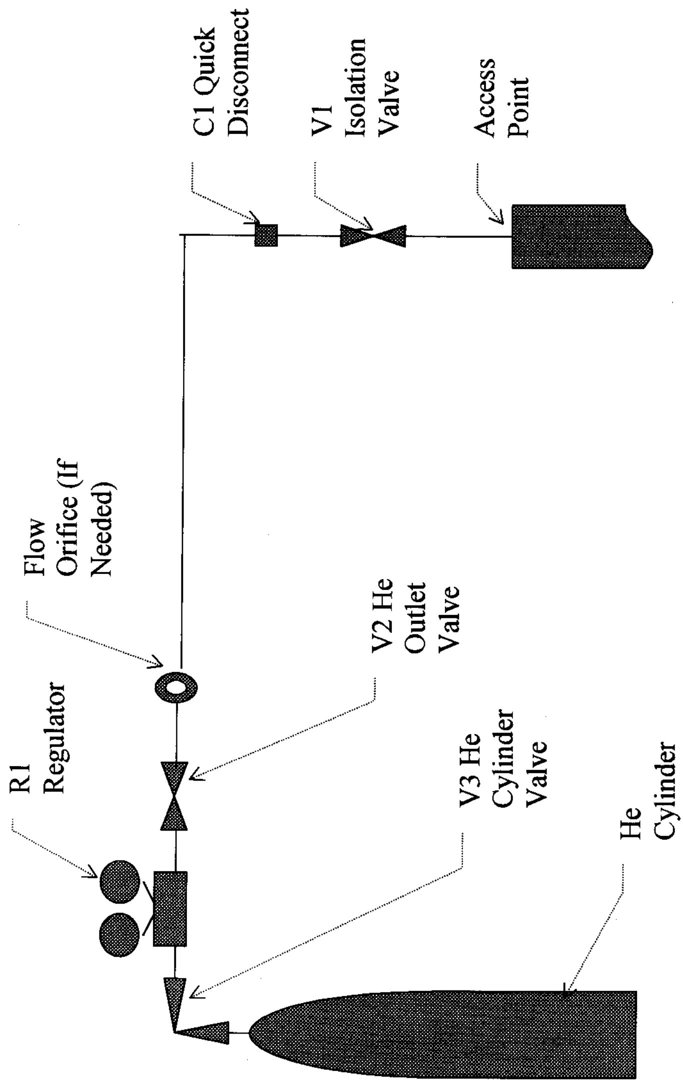

Figure 1. Helium Gas Injection System

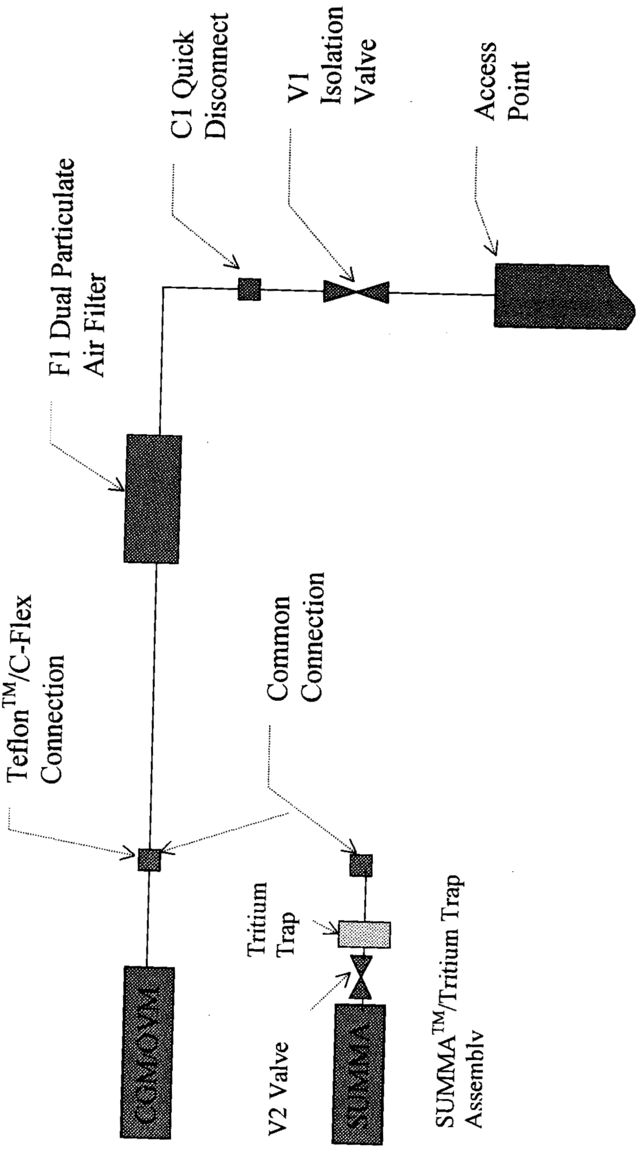

Figure 2. Sampling System

6.0 SAMPLE IDENTIFICATION

Each SUMMA™ sample will be labeled with a unique identification number. This number will also be recorded in the appropriate box on the data sheet form (see Appendix B). Each sample identification number will have the following format:

VXXX-YY-LLLL

Where,

V indicates that the sample is a vapor sample
XXX indicates the tank number (i.e., 152 or 417)
YY: a two-digit code found on the data sheet
LLLL: a laboratory assigned code found on a tag attached to the SUMMA™ canister.

7.0 DATA QUALITY REQUIREMENTS

7.1 REQUIREMENTS FOR FIELD DATA

Test data that will be required from field operations of the tracer gas injection system are identified in the data sheet shown in Appendix B. Anomalies and environmental conditions that could affect sampling results (e.g., usual odors, machinery in operation nearby, etc.) will be noted in the Comments/Observations section of the data sheet. Other data (combustible gas level, organic vapor and ammonia concentrations) shall be recorded as directed in field work packages.

7.2 REQUIREMENTS FOR LABORATORY DATA

SUMMA™ samples collected during tracer gas injection will be analyzed for He concentration only. In the event that the combustible gas level in a catch tank exceeds the established threshold, the SUMMA™ samples collected for vapor gas characterization will be analyzed for the parameters listed in Table 3-2. Suggested laboratory analytical methods and the associated required quantitation limits (RQL), precision, and accuracy for these target analytes are shown in Table 6-1. The analyses shall be performed in accordance with laboratory-approved procedures.

Table 7-1. Suggested Analytical Methods and Laboratory Quality Control Requirements (2 Sheets)

Analyte	Suggested Analytical Method	VPRQL[1] (ppbv)	Precision (%RSD or %RPD)[2]	Accuracy (% Recovery)
Carbon monoxide	GC[3]	5.0	25	70 to 130
Carbon dioxide	GC[3]	5.0	25	70 to 130
Helium	GC[3]	5.0	25	70 to 130
Hydrogen	GC[3]	5.0	25	70 to 130
Methane	GC[3]	5.0	25	70 to 130
Oxygen	GC[3]	5.0	25	70 to 130
Nitrous oxide	GC[3]	5.0	25	70 to 130
Ammonia	Solvent Tube Train/ IC[4]	5.0	25	70 to 130
Freon 12	GC/MS[5]	5.0	25	70 to 130
Methyl chloride	GC/MS[5]	5.0	25	70 to 130
n-Butane	GC/MS[5]	5.0	25	70 to 130
Ethyl chloride	GC/MS[5]	5.0	25	70 to 130
Ethanol	GC/MS[5]	5.0	25	70 to 130
Freon 11	GC/MS[5]	5.0	25	70 to 130
Acetonitrile	GC/MS[5]	5.0	25	70 to 130
Acetone	GC/MS[5]	5.0	25	70 to 130
Furan	GC/MS[5]	5.0	25	70 to 130
n-Pentane	GC/MS[5]	5.0	25	70 to 130
2-Propanol	GC/MS[5]	5.0	25	70 to 130
Dichloromethane	GC/MS[5]	5.0	25	70 to 130
1-Propanol	GC/MS[5]	5.0	25	70 to 130
2-Methyl-pentane	GC/MS[5]	5.0	25	70 to 130
Propanenitrile	GC/MS[5]	5.0	25	70 to 130
Butanal	GC/MS[5]	5.0	25	70 to 130
1-Hexene	GC/MS[5]	5.0	25	70 to 130
2-Butanone	GC/MS[5]	5.0	25	70 to 130
n-Hexane	GC/MS[5]	5.0	25	70 to 130
Chloroform	GC/MS[5]	5.0	25	70 to 130
Tetrahydrofuran	GC/MS[5]	5.0	25	70 to 130
1-Butanol	GC/MS[5]	5.0	25	70 to 130
Benzene	GC/MS[5]	5.0	25	70 to 130
Carbon tetrachloride	GC/MS[5]	5.0	25	70 to 130
Butanenitrile	GC/MS[5]	5.0	25	70 to 130
3-Methyl-hexane	GC/MS[5]	5.0	25	70 to 130
2-Pentanone	GC/MS[5]	5.0	25	70 to 130
n-Heptane	GC/MS[5]	5.0	25	70 to 130
1,4-Dioxane	GC/MS[5]	5.0	25	70 to 130

Table 7-1. Suggested Analytical Methods and Laboratory Quality Control Requirements (2 Sheets)

Analyte	Suggested Analytical Method	VPRQL[1] (ppbv)	Precision (%RSD or %RPD)[2]	Accuracy (% Recovery)
4-Methyl-2-pentanone	GC/MS[5]	5.0	25	70 to 130
Toluene	GC/MS[5]	5.0	25	70 to 130
2-Hexanone	GC/MS[5]	5.0	25	70 to 130
n-Octane	GC/MS[5]	5.0	25	70 to 130
Tetrachloroethylene	GC/MS[5]	5.0	25	70 to 130
Chlorobenzene	GC/MS[5]	5.0	25	70 to 130
Ethylbenzene	GC/MS[5]	5.0	25	70 to 130
m,p-Xylene	GC/MS[5]	5.0	25	70 to 130
3-Heptanone	GC/MS[5]	5.0	25	70 to 130
2-Heptanone	GC/MS[5]	5.0	25	70 to 130
Cyclohexanone	GC/MS[5]	5.0	25	70 to 130
Styrene	GC/MS[5]	5.0	25	70 to 130
n-Nonane	GC/MS[5]	5.0	25	70 to 130
o-Xylene	GC/MS[5]	5.0	25	70 to 130
1,1,2,2-Tetrachloroethane	GC/MS[5]	5.0	25	70 to 130
2-Octanone	GC/MS[5]	5.0	25	70 to 130
n-Decane	GC/MS[5]	5.0	25	70 to 130
1,2,4-Trimethylbenzene	GC/MS[5]	5.0	25	70 to 130

[1]VPRQL: Vapor Program Required Quantitation Limit
[2]RSD: Relative Standard Deviation; RPD: Relative Percent Difference
[3]GC: Gas Chromatography
[4]IC: Ion Chromatography
[5]GC/MS: Gas Chromatography/Mass Spectrometry

Analytical instruments shall be calibrated and maintained according to laboratory procedure(s) or manufacturer's recommendation. Analytical procedures shall be reviewed for concurrence by TWRS Process Engineering prior to analysis. Personnel performing the analyses shall be appropriately trained for their assigned tasks. Calibration, maintenance, and training records shall be available for review when requested by the customer.

Traceability of the SUMMA™ samples shall be maintained through field chain-of-custody and sample shipping/receiving documentation. Laboratory chain-of-custody and/or operating log shall be used to establish traceability for every sample (and sub-sample) undergoing analysis. These records shall also be available upon request.

8.0 ROLES AND RESPONSIBILITIES

The main functions for this activity include an Overall Activity Lead, Field Measurements/Sampling, Laboratory Analysis, and Data Evaluation. All functions must be executed well in order to achieve the test objectives. The relationships among these functions are shown in Figure 3. The functions and the responsible organizations are further discussed below.

Activity Lead: TWRS Process Engineering, representing Safety Issue Resolution, will act in this role. The Activity Lead shall coordinate the entire effort to assure that the desired data will be obtained as scheduled. Specific responsibilities include establishing test specification (i.e., prepare this test plan), assigning task responsibilities, and resolving sampling issues as they occur.

Field Measurement/Sampling: This function consists of pre-work planning activities and the actual field sampling. TWRS Characterization Engineering will be responsible for completing the pre-work planning. Specific responsibilities include preparing work packages, performing Unreviewed Safety Question (USQ) screening, conducting field verification of sampling locations, and verifying final configuration of the test equipment. In addition, TWRS Characterization Engineering will communicate and obtain necessary approvals from TWRS Double-Shell Tank and Single-Shell Tank Engineering groups.

Characterization Project Operations (CPO) will be responsible for coordinating and performing the fieldwork. Specific responsibilities include arranging the necessary resources (personnel, materials, and equipment) for each sampling event and collecting data and samples as specified in this test plan. In addition to ensuring the availability of primary personnel (i.e., sampler and Industrial Hygiene), CPO will coordinate secondary support such as Radiation Protection and Crafts as needed. CPO will assure that field measurements are taken and recorded properly and that SUMMA™ samples will be traceable through proper identification and chain-of-custody.

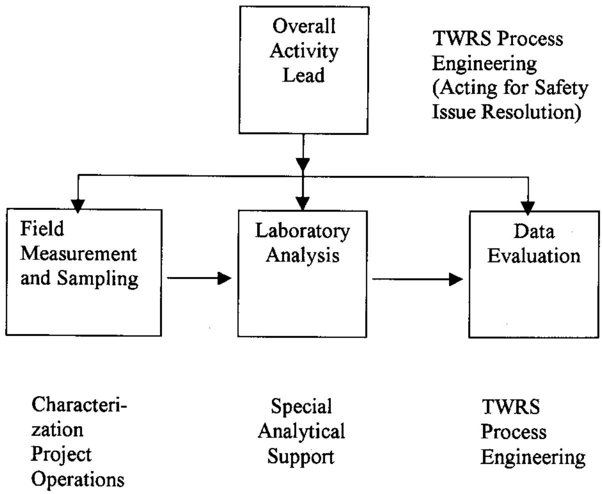

Figure 3. Lead Roles for the Sampling Activity

Laboratory Analysis: SUMMA™ samples will be analyzed for helium concentrations or analytes listed in Table 3-2 as appropriate. Special Analytical Support (SAS) will supply clean SUMMA™ canisters and tritium traps and be responsible for performing the analysis.

All analytical data shall be independently reviewed and approved by qualified personnel. A data report shall be transmitted to the Activity Lead only and shall contain the following information at a minimum:

- A brief narrative of the sample preparation, analysis, and quality control/quality assurance measures,
- Concentration(s) of target analyte(s) for each sample,
- Quality control data to document achieved precision and accuracy, and
- Appropriate RQL if an analyte is not detected.

In addition, the data report shall include a discussion of every characterization issue or data anomaly, resolution of each issue/anomaly, and the impact on the data.

Data Evaluation: Analytical data will be evaluated against process knowledge and existing data if available. Ventilation rates for tanks 241-AX-152 and 241-A-417 will be calculated. TWRS Process Engineering will be responsible for performing this evaluation. Results of the evaluation and a summary of the data will be documented in a report.

9.0 SAFETY CONSIDERATIONS

Pressurized helium in steel bottles will be used for the tracer gas injection. Proper precautions will be taken when handling pressurized gas bottles. The catch tanks may contain hazardous vapor and radionuclides. A survey for hazardous vapor will be performed prior to gaining access to a tank. Also, radiation and hazardous vapor will be monitored during the test as necessary.

10.0 TEST PROCEDURE

10.1 TRACER GAS INJECTION

Note: For catch tanks 241-AX-152 and 241-A-417, the combustible gas level measurements (See Section 10.2) must be completed prior to performing tracer gas injection.

Helium Injection Procedure (Refer to Figure 1):

1. Verify that the gas cylinder contains helium at pressure <800 psig.
2. Connect a single ended, shut-off, quick disconnect body (e.g., Swagelok part #QC4) to the assigned attachment point for the sample.
3. Connect the helium injection system to the assigned tank access point at connection C1 as directed by the field work package.
4. Verify that the helium outlet valve is closed.
5. Measure the helium cylinder starting pressure by opening the helium cylinder valve (V3), and adjust the pressure regulator as specified in the work package.
6. Record the starting helium cylinder starting pressure as indicated by the pressure regulator digital high-pressure stage gauge.
7. Measure and record the helium cylinder temperature.
8. Open the assigned sample line isolation valve (V1).
9. Begin tracer gas injection by opening the helium outlet valve (V2).
10. Observe the bottle pressure as indicated by the digital high-pressure stage gauge on the pressure regulator. When the pressure reaches the stopping pressure as specified in the work package, stop helium flow by closing the helium outlet valve (V2).
11. Close the assigned sample line isolation valve (V1).
12. Verify that the helium outlet valve (V2) is closed.
13. Measure the helium cylinder final pressure using the digital high-pressure stage gauge; record the helium cylinder final pressure.
14. Close the helium cylinder valve (V3).

15. Disconnect the helium injection system as directed by the field work package.

Procedure for Collecting the First Set of SUMMA™ Samples (Refer to Figure 2):

16. Verify that the specified time interval has elapsed since completion of the helium injection.

17. Connect (in series) two particulate air filters to the quick-disconnect installed on the sample line. The particulate air filters (F1) shall be closest to the tank access point.

18. Place a short piece of Teflon™ (or c-flex) tubing down stream of the dual particulate air filter (F1). This will allow a quick connection between the CGM/OVM and the SUMMA™/tritium trap assembly.

19. Connect the CGM/OVM to the Teflon™ (or c-flex) tubing.

20. Open the sample line isolation valve (V1).

21. Purge the sample line using the CGM/OVM for the duration specified in the field work package.

22. Close the isolation valve (V1).

23. Disconnect the CGM/OVM from the Teflon™ (or c-flex) tubing.

24. Connect the SUMMA™/tritium trap assembly.

25. Open the isolation valve (V1).

26. Collect the first SUMMA™ sample per field work package and record the data required on the data sheet.

27. Close the isolation valve (V1).

28. Disconnect the SUMMA™/tritium trap assembly from the Teflon™ (or c-flex) tubing. Disconnect the tritium trap from the SUMMA™ canister.

29. Repeat Steps 24 through 28 to collect the second SUMMA™ sample.

30. Configure the assigned tank access point to the condition specified in the fieldwork package.

Procedure for Collecting the Second Set of SUMMA™ Samples (Refer to Figure 2):

31. Verify that the specified time interval has elapsed since completing collection of the first set of SUMMA™ samples.

32. Repeat Steps 17 through 30 to collect the second set of SUMMA™ samples.

10.2 FIELD COMBUSTIBLE GAS LEVEL MEASUREMENTS

Ammonia concentration, organic vapor and combustible gas levels in tank headspace shall be measured after purging the sample line with headspace gas. The instruments listed in Table 3-1 shall be calibrated and operated in accordance with the operating manuals by qualified personnel. The data shall be recorded as directed in field work packages.

If the combustible gas level in a tank as measured by the CGM exceeds 25% of the LFL, the following procedure will be followed to collect three SUMMA™ samples (Refer to Figure 2):

1. Connect a single ended, shut-off, quick disconnect body (e.g., Swagelok part #QC4) to the assigned attachment point for the sample.

2. Connect (in series) two particulate air filters to the quick-disconnect installed on the sample line. The particulate air filters (F1) shall be closest to the tank access point.

3. Place a short piece of Teflon™ (or c-flex) tubing down stream of the dual particulate air filter (F1). This will allow a quick connection between the CGM/OVM and the SUMMA™/tritium trap assembly.

4. Connect the CGM/OVM to the Teflon™ (or c-flex) tubing.

5. Open the sample line isolation valve (V1).

6. Purge the sample line using the CGM/OVM for the duration specified in the field work package.

7. Close the isolation valve (V1).

8. Disconnect the CGM/OVM from the Teflon™ (or c-flex) tubing.

9. Connect the SUMMA™/tritium trap assembly.

10. Open the isolation valve (V1).

11. Collect the first SUMMA™ sample per field work package.

12. Close the isolation valve (V1).

13. Disconnect the SUMMA™/tritium trap assembly from the Teflon™ (or c-flex) tubing. Disconnect the tritium trap from the SUMMA™ canister.

14. Repeat Steps 9 through 13 to collect the second and third SUMMA™ sample.

15. Configure the assigned tank access point to the condition specified in the fieldwork package.

10.3 RADIATION SCREENING

Tritium traps and particulate air filter assemblies will be shipped by CPO to the Waste Sampling and Characterization Facility (WSCF) for analysis. The tritium traps will be analyzed for tritium; the air filters will be analyzed for total alpha, total beta, and gamma energy analyses. Radiation Protection will use the data to determine whether or not the SUMMA™ samples can be radiologically released (and therefore can be accepted by the laboratory). CPO will store the SUMMA™ samples until they are released and will ship them to the laboratory at that time.

11.0 REFERENCES

Bauer, R. E., 1998, *Test Plan for Headspace Gas Concentration Measurements and Headspace Ventilation Rate Measurements for DCRTs 241-A-244, 241-BX-244, 241-S-244, and 241-TX-244*, HNF-2543, DE&S Hanford, Inc., Richland, Washington.

Bauer, R. E. and Hedengren, D. C., 1999, *Headspace Gas Concentration Measurements and Headspace Ventilation Rate Measurements for Double-Contained Receiver Tanks 241-A-244, 241-BX-244, 241-S-244, and 241-TX-244, HNF-2923, Rev. 0-A,* DE&S Hanford, Inc., Richland, Washington.

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APPENDIX A

METHOD FOR CALCULATING VENTILATION RATE IN A CATCH TANK

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METHOD FOR CALCULATING VENTILATION RATE IN A CATCH TANK

Where V: volume of headspace (volume of tank – volume of liquid)
Q: ventilation rate
x: concentration of helium at any given time after gas injection

Mass balance for helium:

Rate of helium out – Rate of helium in = Rate of helium loss

The rate of helium entering the tank after completion of gas injection can be considered negligible. The mass balance equation can be re-written as:

$$Qx = -V\frac{dx}{dt} \tag{1}$$

Or $$dt = \frac{-V}{Q}\frac{dx}{x} \tag{2}$$

Integration of Equation (2) gives:

$$\int_1^2 dt = \frac{-V}{Q}\int_1^2 \frac{dx}{x}$$

$$\Delta t = \frac{-V}{Q}(\ln x_2 - \ln x_1)$$

$$\Delta t = \frac{V}{Q}\ln\frac{x_1}{x_2}$$

Or $$Q = \frac{V}{\Delta t}\ln\frac{x_1}{x_2} \tag{3}$$

x_1 and x_2 will be determined from analysis of the SUMMA™ samples. Δt is the time interval between collection of the two sample sets.

Equation (3) can be re-written as follow for the period between gas injection and collection of the first set of SUMMA™ samples (Δt_o):

$$Q = \frac{V}{\Delta t_o} \ln \frac{x_o}{x_1} \tag{4}$$

x_o, the initial concentration of helium in the tank, can be estimated as follows:

Assume helium behaves as an ideal gas:

PV = nRT

$$nR = \frac{P_c V_c}{T_c} = \frac{P_o V_o}{T_o} \tag{5}$$

Where P_c, V_c, and T_c are pressure, volume, and temperature of helium in the gas cylinder and P_o, V_o, and T_o are the same properties of helium in the catch tank immediately after injection.

Equation (5) can be re-arranged to:

$$V_o = V_c \frac{P_c}{P_o} \frac{T_o}{T_c} \qquad 6)$$

The initial concentration of helium in the catch tank after completion of the gas injection is:

$$x_o = \frac{V_o}{V} \tag{7}$$

Three significant assumptions are associated with the calculation of x_o: one, helium behaves like an ideal gas; two, ambient temperature is the same as that in the tank vapor space (This assumption is necessary because there are no temperature probes in the catch tanks); and three, the rate of helium loss during gas injection is negligible. Because of these assumptions, ventilation rates should be calculated based on data from analyses of the SUMMA™ samples. Calculation of the ventilation rate using helium gas bottle data will be performed for verification.

APPENDIX B

DATA SHEET FOR USE WITH TRACER GAS INJECTION

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TRACER GAS INJECTION DATA SHEET							
Catch Tank Number:							
Data Description	**Sample No.**	**Date**	**Time**		**Pressure**		**Recorded By**
			Start	**Stop**	**Start**	**Stop**	
Gas Injection	NA[1]						
Gas Cylinder Temperature: ________°F				NA	NA	NA	
Ambient Air Temperature: ________°F				NA	NA	NA	
Sample Set 1	Canister 1 #: V____-A1-_____				NA	NA	
	Canister 2 #: V____-A2-_____				NA	NA	
Ambient Air Temperature: ________°F				NA	NA	NA	
Sample Set 2	Canister 1 #: V____-B1-_____				NA	NA	
	Canister 2 #: V____-B2-_____				NA	NA	
Ambient Air Temperature: ________°F				NA	NA	NA	
Comments or Observations:							

[1]NA: Not Applicable

__Note:__ Temperature measurements should be performed during (or as close as possible to) the gas injection or sampling.

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DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Models and Inventory	Date 03/09/99
Project Title/Work Order		EDT No. EDT-611453
HNF-4082, Rev. 0, "Test Plan for Measuring Ventilation Rates and Combustible Gas Levels in TWRS Active Catch Tanks"		ECN No. N/A

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