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HYDROGEN MITIGATION GAS CHARACTERIZATION SYSTEM SYSTEM DESIGN DESCRIPTION

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Gas Characterization System (GCS) system design description for flammable gas monitoring.

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HYDROGEN MITIGATION

GAS CHARACTERIZATION SYSTEM

SYSTEM DESIGN DESCRIPTION

HNF-2957

PREPARED BY

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July 1998

TWRS Safety Special Projects

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1.0 INTRODUCTION

1.1 BACKGROUND

Tank 241-SY-101 (SY-101) is known to experience periodic tank level increases and decreases during which hydrogen gas is released. It is believed that the generated gases accumulate in the solids-containing layer near the bottom of the tank. Solids and gases are also present in the "crust" and may be present in the interstitial liquid layer. The accumulation of gases creates a buoyancy that eventually overcomes the density and bonding strength of the bottom layer. When this happens, the gas from the bottom layer is released upward through the liquid layer to the vapor space above the tank crust. Previous monitoring of the vapor space gases during such an event indicates hydrogen release concentrations greater than the lower flammability limit (LFL) of hydrogen in a partial nitrous oxide atmosphere.

Tanks 241-AN-105, 241-AW-101, and 241-SY-103 have been identified as having the potential to behave similar to SY-101. These waste tanks have been placed on the flammable gas watchlist (FGWL). All waste tanks on the FGWL will have a standard hydrogen monitoring system (SHMS) installed to measure hydrogen. In the event that hydrogen levels exceed 0.75% by volume, additional characterization will be required. The purpose of this additional vapor space characterization is to determine the actual lower flammability limit of these tanks, accurately measure low baseline gas release concentrations, and to determine potential hazards associated with larger Gas Release Events (GREs).

The instruments to be installed in the Gas Characterization System (GCS) for vapor monitoring will allow accurate analysis of samples from the tank vapor space. It will be possible to detect a wide range of hydrogen from parts per million (ppm) to percent by volume, as well as other gas species suspected to be generated in waste tanks.

1.2 SCOPE

This document describes the design of the GCS gas sampling and analysis systems, as well as the systems needed to support operation. Two dual column gas chromatographs (GC), and one Fourier transform infrared spectrometer (FTIR) will be the analytical instruments employed to provide the vapor space gas monitoring for hydrogen and other gas species suspected to be generated in waste tanks, such as nitrous oxide (N_2O), ammonia (NH_3), and methane (CH_4).

2.0 FUNCTIONS AND DESIGN REQUIREMENTS

The primary function of the GCS is to provide an environmentally controlled facility to sample the 241-AN-105 and 241-AW-101 exhaust duct gases and analyze the sampled gases for hydrogen as well as other suspected gas species, which include, but are not limited to methane, nitrous oxide and ammonia. Currently of the 177 radioactive waste tanks on the Hanford Project site, twenty five (6 Double Shell and 19 Single Shell Tanks) were identified as having the potential for the buildup of gases to a flammable level. Of these 25 waste tanks, AN-105 and AW-101 have been identified as requiring additional characterization. Analyzing the tank vent gases is required to determine the magnitude and time dependence of the various gases released from these tanks.

The general equipment requirements include sensor operational lifetimes, with periodic preventative maintenance, of at least one year based upon vendor data. The equipment was selected on a best available technology basis to provide usable and traceable analytical data.

The GCS data system will store and archive analytical gas monitoring data, as well as process variables such as temperature and pressure.

The engineering tasks will comply with the requirements specified in WHC-SD-WM-ETP-143, *TWRS Hydrogen Mitigation Gas Characterization System Design and Fabrication Engineering Task Plan.*

2.1 SYSTEM CLASSIFICATION

This system is classified as General Service in accordance with the requirements of HNF-PRO-704, *Hazards and Accident Analysis Process*. Although the GCS function is not safety class or safety significant, its connection with the tank vapor space does demand potential spark source isolation. Defense-in-Depth may necessitate some protective equipment as Safety Equipment List components.

2.2 TEST FACILITY REQUIREMENTS

It is necessary to provide a habitable facility to house scientific equipment for the analysis of waste tank vapor space gases. The gas characterization building is similar to the one used for the gas monitoring facility (GMS-2) on SY-101. The analysis for the (GMS-2) shelter installation, structural analysis and seismic analysis for equipment anchorage are presented in WHC-SD-WM-DA-085, *241-SY-101 Gas Monitoring System Design Support Analysis*. The facility requirements shall meet the following:

2.2.1 The facility shall be installed in an unprotected area of the waste tank farm.

2.2.2 The facility shall be environmentally controlled in order to maintain the analytical equipment in an acceptable environment. The following external conditions exist:
- air temperature of -23 to +38 °C (-10 to +100 °F)
- relative humidity of 5 to 100% condensing
- wind speeds up to 31.8 m/s (70 miles/hour)
- rain, snow, sleet, lightning, hail, and blowing sand and dust
- radiation up to 100 mr/hour

2.3 SAMPLE GAS DELIVERY SYSTEM REQUIREMENTS

It is necessary to provide a gas sample delivery system. The gas sample delivery system has the following required features:

2.3.1 Provides the ability to draw a tank gas sample under pressures between -2.99 and +14.9 kPa (-12 and +60 inches of water) and be able to structurally withstand temperatures between -10 and 100°C (14 and 212 °F) and condensed vapors considered to have a pH between 8 and 12.

2.3.2 Provides the sampled gas from the sample point to the analytical instruments in less than 5 minutes and maintain sample delivery speed upon isolation of any analytical instrument. (The sample gas delivery time analysis is include in Appendix C in this document.)

2.3.3 Provides two sub-micron sample gas inlet filters inside the GCS building with differential pressure indication.

2.3.4 Provides the capability to isolate individual sample line components, as practical, for maintenance.

2.3.5 Provides the necessary fittings, filters, valves, piping, and sample containers to allow tank vapor space gas samples to be captured and transported to a laboratory for analysis.

2.3.6 Provides manual sample gas flow control, with local flow and pressure indication.

2.3.7 Provides exterior sample gas lines heat traced to maintain a minimum sample temperature of 30°C (86°F) to avoid condensate buildup.

2.3.8 Provides manual sample isolation valves located as close to the tank sample and return points as possible.

2.3.9 Provides manual isolation valves located in the sample system in such a way to minimize large volumes of trapped gas that would dilute the analyzed sample or calibration gases.

2.3.10 Provides equipment arrangement to allow ease of operation with a consideration for system expansion.

2.3.11 Provides HEPA quality filtration of dilute analyzed sample vented to the environment.

2.4 SAMPLE GAS ANALYTICAL SYSTEM REQUIREMENTS

Process instrumentation, such as flow, pressure, and temperature shall be provided in the following accuracies:

Measured Parameter	Accuracy
Temperature	± 2 °C
Absolute Pressure	± 1% of Full Scale
Differential Pressure	± 1% of Full Scale
Flow Rate	± 10% of Full Scale

The sample gas analytical system shall consist of two dual column gas chromatographs and one Fourier transform infrared (FTIR) spectrometer with the following measurement ranges and accuracies for a gaseous mixture consisting primarily of moist air with concentrations of gases listed below:

Measured Gas	Range	Accuracy
H_2	3 - 30 ppm	± 3 ppm
	30 - 30,000 ppm	± 10% of Reading
CH_4	10 - 100 ppm	± 10 ppm
	100 - 30,000 ppm	± 10% of Reading
NH_3	3 - 30 ppm	± 3 ppm
	30 - 10,000 ppm	± 10% of Reading
N_2O	10 - 30 ppm	± 3 ppm
	30 - 30,000 ppm	± 10% of Reading

The gas grab sample system will allow a selected gas sample to be captured and taken to a laboratory for independent analysis.

Local displays of analyzed gas samples shall be provided, as well as local and remote data logging capabilities through a high speed data link.

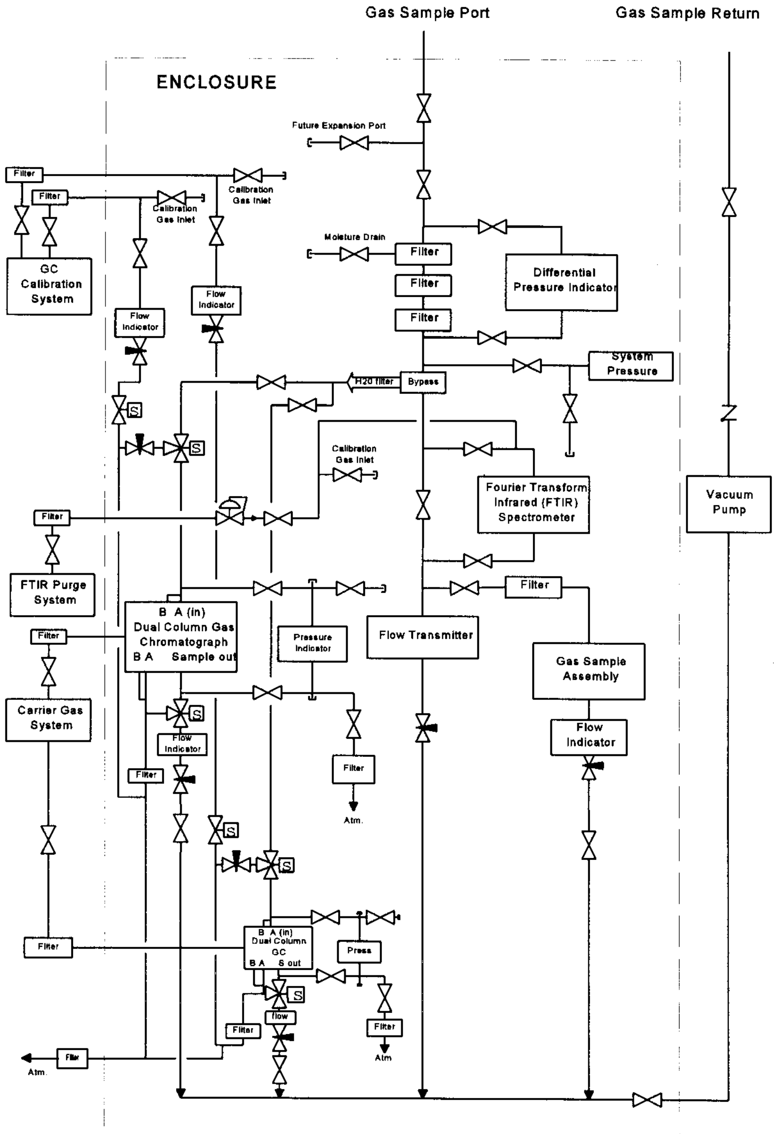

Figure 1 - SYSTEM BLOCK DIAGRAM

3.0 DESIGN DESCRIPTION

The GCS design includes several major subsystems which make up the AN-105 and AW-101 exhaust header gas monitoring and analysis system (see Figure 1). The system PI&D presented on H-14-100435 functionally depicts the overall system.

- The gas sampling pneumatic system is composed of tubing, valves, filters, and a vacuum pump which delivers the sample to the analytical instruments.
- The sampling process instrumentation includes process temperature, pressure, and flow instruments to characterize the sample being delivered.
- The five analytical instruments (the two dual column GCs and the FTIR) perform the actual measurement and display and then transmit the analyzed gas and process data to the data system file server for access by the designated review teams.
- The calibration gas system provides standard gases to the analytical instruments to validate that the data being obtained is accurate.
- The nitrogen or air purge gas system allows the FTIR to obtain a background level prior to its validation and operation.
- The grab sample system provides the on-line capability to obtain an independent analysis of the tank gas sample.
- The power distribution system is composed of 1) unconditioned AC power for lighting, HVAC and system support equipment; 2) conditioned AC power for the instrumentation systems, including the local GC, FTIR, and data computer systems.
- The sample line heat trace system ensures that the sample vapors do not condense (or freeze) within the sample tubing before or following analysis.
- The facility HVAC system provides the condensate protection internal to the shack. The HVAC system also maintains the shack ambient temperature within the analytical instruments' specified operating range, minimizing the data errors due to temperature variations.

3.1 GAS SAMPLING PNEUMATIC SYSTEM

The gas sampling pneumatic system includes all the components that deliver the sample to the analytical instruments and return the sample to the tank exhaust header.

3.1.1 System Tubing

The system tubing is 300 series stainless steel in order to withstand the potentially corrosive gases being sampled. The main sample delivery line between the tank exhaust duct and the GCS building is 1.27 cm (1/2 inch) diameter to allow rapid sample transport and to present a reasonable surface area to volume ratio to minimize plating of gas components on the tubing walls. The sample branch tubing was sized for proper interface to the instruments while maintaining the sample delivery rate and minimizing volumes which trap sample or calibration gases.

3.1.2 System Isolation Valves

The sample isolation valves (SV-*01, SV-*04, ...) are constructed of 300 series stainless steel. Ball valves are selected to provide minimal flow restrictions in the gas sample lines as well as positive indication of valve position during system operation. Instrumentation isolation valves are provided to allow in-place instrument calibration.

3.1.3 Sample Inlet Filter System

Three sample inlet filters are provided to reduce the potential for system contamination. The first filter (FLT-*10) is utilized to trap moisture and particles of 25 microns or larger. The next two filters (FLT-*11, FLT-*12) are designed to individually trap particles of 0.2 microns and larger at a 99.9% efficiency at the planned system flow rates. A differential pressure gauge (PDI-*10) with isolation valves (SV-*6,-*7,-*8,-*9) are installed across the inlet filter to monitor for plugging.

3.1.4 Gas Chromatograph Sample Gas Loops

The main sample line is routed near the GC instrument rack in order to provide rapid sample delivery to each instrument. The individual GC sample lines are provided with isolation valves (SV-*20, SV-*27, SV-*30, SV-*37). The 0.3175 cm (1/8 inch) sample lines are reduced to 0.1588 cm (1/16 inch) at the instrument rack bulkhead connectors. The 0.1588 cm (1/16 inch) lines provide for flexibility in order to slide the GCs out of the rack for maintenance without disconnecting the gas lines. The sample line instrumentation will be discussed in section 3.2.

3.1.5 FTIR Sample Gas Loops

The main sample line is routed through the FTIR sample gas cell (NE-*40) downstream of the GC sample points. Isolation valves (SV-*40, SV-*41) are provided in order to remove the sample cell for maintenance or exchange. A bypass line and isolation valve (SV-*12) is provided to allow normal sample flow during the FTIR cell maintenance. Flexible stainless lines are connected to the sample cell to minimize cell vibration, and aid in minor cell movement and maintenance. A cell pressure relief valve (PRV-*40) is provided to prevent cell over pressurization. The relieved gases vent to the environment through HEPA quality depth filters (FLT-*40 and FLT-*41). The associated process instrumentation will be discussed in Section 3.2.

3.1.6 Sample Flow Control Valve

The main sample line includes a 300 series stainless steel laminar flow element (FE-*10) and flow control valve (SV-*13). The manual flow control valve will be used to adjust the flow to the desired rate as measured by the flow element. Since the system has a dedicated sample pump, the manual valve provides adequate flow control for the GC and the FTIR systems. The associated flow instrumentation will be discussed in section 3.2.

3.1.7 Sampling Vacuum Pump

The sampling pump (P-*10) is a completely sealed stainless steel bellows pump with stainless steel valves and viton valve seats. The pump is designed to transport the sample in a closed loop system. All electrical connections are isolated from the sample stream allowing it to pump potentially hazardous and flammable gases.

3.1.8 Sample Exhaust Backflow Preventer

The sample exhaust backflow preventer (SV-*19) is installed in the sample gas return line downstream of the pump. The pump returns the sample gases to the AN-105 and AW-101 tank exhaust header at the same point as the Standard Hydrogen Monitoring System (SHMS). The sample pump can develop in excess of 276 kPa (40 psi) outlet pressure with an obstruction in the outlet line. The purpose of the backflow preventer is to reduce the possibility of other gases flowing back into the GCS sampling loop during a faulted condition.

3.2 GAS SAMPLING INSTRUMENTATION SYSTEMS

The gas sampling instrumentation systems include the sample gas process instruments, the gas analysis and signal conditioning, and data analysis, storage and transmission. The accuracies listed in this section are limited to the individual instruments. Total system accuracy must include dropping resistor accuracies, temperature effects, readout and data logger accuracies.

3.2.1 Main Sample Line

The main sample gas line process instruments provide inlet filter differential pressure, sample inlet pressure and flow indication.

3.2.1.1 Inlet Filter Differential Pressure

A differential pressure indicator (PDI-*10) is installed across the filters to provide guidance on when to maintain the filters. When a pressure drop of 13.7 kPa (55″ H_2O) or greater is indicated across the filters, the filter elements should be replaced to minimize the potential migration of contaminates through the filters. The gauge is rated up to an ambient operating temperature of 93°C (200°F). The differential pressure range is 0 to 14.9 kPa (0 to 60″ H_2O). The accuracy is $\pm 2\%$ (ascending).

3.2.1.2 Sample Inlet Pressure

The inlet pressure indicating transmitter (PIT-*10) monitors the sample gas delivery pressure in the range of 0 to 207 kPa (0 to 30 psia) with an accuracy of ±0.1% of span. The process gases are isolated from the signal conditioning of the transducer by a stainless steel process diaphragm, a capillary of silicon fluid, and a second transducer diaphragm.

3.2.1.3 Sample Flow Indication

The sample flow measurement is obtained using a stainless steel laminar flow element (FE-*10) and a differential pressure indicating transmitter (FIT-*10). The flow indicating transmitter has a range of 0 to 2.49 kPa (0 to 10 inches of water) with an accuracy of ±0.2% span and construction equal to that of the absolute pressure transducer. The flow element provides a differential pressure of 0 to 1.99 kPa (0 to 8 inches of water) for a flow of nominally 0 to 0.757 SL/S (0 to 1.6 SCFM), and is calibrated to an accuracy of ±1% of full scale.

3.2.2 Gas Chromatograph Instrumentation

The GC instrumentation includes the chromatograph columns and detectors, the signal and control processor, process differential and absolute pressure transmitters, and sample flow control and indication. The two dual column GCs each have different range and/or species of gas monitoring. The first GC (NT-*20) is configured to measure hydrogen. The first column measures hydrogen in the range of 3 to 3,000 ppm by volume and the second measures hydrogen in the range from 300 to 30,000 ppm hydrogen by volume.

The second GC (NT-*30) is configured to measure a wide range of gas species including but not limited to nitrous oxide (N_2O) and methane (CH_4). The first column measures N_2O in the range from 3 to 3,000 ppm and CH_4 in the range from 10 to 5,000 ppm. The second column measures N_2O in the range from 300 to 30,000 ppm and CH_4 in the range from 300 to 30,000 ppm. All of the GCs will be calibrated in place using standard calibration gases, to be discussed in the Calibration, Carrier, and Purge System section of this document.

Even though the low and high range columns are specified differently, there should be good agreement between the columns even below 100ppm.

3.2.2.1 Chromatograph Columns and Detector

The GC sample gas system utilizes 0.1588 cm (1/16 inch) and smaller stainless steel tubing to contain the process sample gas and the associated carrier gas. The sample gas valve is controlled by the system and automatically switches the sample gas from a standard volume into the detector columns, for a controlled time, and drives it through the columns with the carrier gas. At a prescribed time, the detector analyzes the gas exiting the column. The GC monitoring for the high and low levels of hydrogen uses a molecular sieve column and a Thermal Conductivity Detector (TCD) while the GC monitoring for the low and high levels of methane and nitrous oxide utilizes a poraPLOT Q column and a thermal conductivity detector.

3.2.2.2 Differential Pressure

A differential pressure transducer measures the pressure drop across each GC. The differential pressure indicating transmitters (PDIT-*20, PDIT-*30) have a range of -17 to 45 kPa (-70 to 180 inches of water) with an accuracy of 0.2% of span. The process gases are isolated from the signal conditioning of the transducer by a stainless steel process diaphragm, a capillary of silicon fluid and a second transducer diaphragm. Proper positioning of the manual valves associated with the PDITs will also allow the GC inlet pressures to be monitored. It is important to maintain similar inlet pressures during tank gas and calibration gas sampling to assure accurate comparison of the gas analysis.

3.2.2.3 Sample Flow Control and Indication

The GC sample flow indication and control is accomplished by small purge rotameters with integral flow control valves. The flow indicators (FI-*20, FI-*30) and control valves (SV-*26, SV-*36) are located downstream of the GCs in order to keep the sample gas pressure as close to atmosphere as possible. The purge meters have a range of 0-46 cc/min and an accuracy of $\pm$10% of full scale.

3.2.3 FTIR Instrumentation

The FTIR instrumentation includes the infra-red light source and detection system, the signal processor, the detection cell sample gas temperature measurement, the detection cell sample gas absolute pressure measurement, and the sample gas flow measurement. The FTIR system is used to detect and analyze a wide range of gas species including but not limited to nitrous oxide (N_2O), ammonia (NH_3), and carbon dioxide (CO_2). The FTIR and one of the dual column GCs may be used to compliment the data taken on the wide range of gas species; however, the FTIR is only required to report data on ammonia analysis.

3.2.3.1 Light Source and Detection System

The FTIR uses a ceramic infrared light operating in the mid-infrared region as a light source for an interferometer (an optical device for determining the wavelength of light). The light passes through the sample gas and creates an interference pattern on a pyroelectric detector. This pattern is unique for each different gas component. A helium-neon laser is used as a reference signal for optical alignment and pathlength verification.

3.2.3.2 Signal Processing System

Analog-to-digital converters process the detector signal to a form that the FTIR computer can use. The computer controls a movable mirror in the interferometer cavity to determine the light intensity versus wavelength (absorption spectra). The FTIR computer displays the spectrum of the gas sample on its screen using vendor supplied software and can send the data to the GCS Data System upon request via an RS-232 digital communications line or ethernet.

3.2.3.3 Cell Sample Gas Temperature

The cell sample gas temperature monitor combines an RTD (TE-*40) and an accurate signal conditioner with a local digital readout (TIT-*40) and provides a 4-20 mA analog output. The RTD is encased in a series 316 stainless steel welded jacket, which provides a protective barrier between the RTD and the potentially hazardous sample gas.

The accuracy of the RTD is ±0.15% +0.002 X °C (actual temperature).

The accuracy of the readout transmitter is ±0.2 °C ± ½ least significant digit (LSD).

3.2.3.4 Cell Sample Gas Absolute Pressure

The FTIR cell sample pressure indicating transmitter (PIT-*40) monitors the sample gas pressure in the range from 0 to 207 kPa absolute (0 to 30 psia) with an accuracy of ±0.1% of span. The process gases are isolated from the signal conditioning of the transducer by a stainless steel process diaphragm, a capillary of silicon fluid and a second transducer diaphragm.

3.2.3.5 Sample Gas Flow Indication

The FTIR sample gas flow indicator and transmitter are the same devices discussed in 3.2.1.3 above, since the main sample flow passes through the FTIR cell.

3.2.4 Process Instrumentation/Data Logger Interfaces

The process instrumentation, monitoring pressure, temperature and flow, is interfaced to the GCS Data System via 4-20 mA current loops and discrete contact closures through A/D cards and direct digital input cards in the data system. The analytical instrumentation utilizes digital data links to transmit their processed data to the GCS data system for display and recording.

3.3 CALIBRATION, CARRIER, AND PURGE GAS SYSTEM

The calibration, carrier, and purge gas system is configured into four sections which include the automatic GC calibration gas supply, the manual GC and FTIR calibration gas supply, the GC carrier gas supply, and the FTIR manual purge gas supply. All of the gases used in conjunction with the GCS systems are certified specialty mixed gases.

3.3.1 Automatic Calibration Gas Supply

The automatic GC calibration gas supply utilizes two standard gas bottles mounted in the local bottle rack adjacent to the GCS building. The bottle regulators (PCV-*61, PCV-*63) are set to a prescribed low psi value determined empirically, in conjunction with the manual calibration gas metering valves and flow meters (FIV-*20, FIV-*30), to provide a constant gas bypass flow of nominally 470 cc per minute (1 CuFt/Hr) passed a calibration gas sample volume. Flow control valves (SV-*21, SV-*31) adjust the GC calibration gas inlet pressure and flow to be consistent with the tank sample gas inlet pressure and flow conditions.

The manual isolation valves (SV-*61, SV-*63, SV-*28, SV-*38) are normally open to allow the calibration gas to flow to the selected GC as directed by the electrically controlled isolation valves. The selected GC isolation valves (SOV-*20, SOV-*30) are controlled in conjunction with the GC sample source selection valves (SOV-*21, SOV-*31) by the data system, when the system performs a routine automatic calibration. When the calibration is complete, the electrically controlled isolation valve is closed and the sample source selection valve is switched to again permit tank sample gas to flow through the GC.

3.3.2 Manual Calibration Gas Supply

The manual GC calibration gas is supplied in small, portable, low pressure lecture bottles that are pressure regulated to nominally the same pressure as the automatic calibration gas system. A set of isolation valves (SV-*29, SV-*39, SV-*49) direct the pressure regulated standard gases to the selected instrument to be calibrated. The calibration gas bottle is connected to the regulator (PCV-*65) and associated isolation valve (SV-*69) and then to the appropriate instrument isolation valve via a flexible stainless steel metal hose. The operator directs the electrically controlled isolation and gas selection valves to open via the data system keyboard.

The manual FTIR calibration gas is supplied in large full sized bottles positioned outside the enclosure. A wall penetrating 1/4 inch stainless steel tube and flexible stainless steel metal hose provides the interface to the FTIR cell isolation valve (SV-*49). The operator provides tank sample gas isolation to the cell by closing the cell isolation valve (SV-*40) and then regulates the calibration gas flow and cell pressure, after opening isolation valve (SV-*49), to simulate normal operating conditions. The FTIR ammonia calibrating gas cannot be delivered to a static cell, since the ammonia will attach itself to the cell walls and provide erroneous analysis values. Following analytical validation checks, the isolation valves are positioned to return tank gas sample flow.

3.3.3 Carrier Gas Supply

The GC carrier gas supply is provided through two manifolds in the gas bottle rack adjacent to the GCS building. Each manifold supports two bottles of gas and a single pressure regulator. The manifold pressure regulators (PCV -*60, PCV-*62) and the internal GC pressure control valves control the carrier gas pressure to supply the required carrier gas flow for each of the GCs. It is imperative that the carrier gas continue to flow in the GCs during gas bottle change out to maintain the operating conditions. The selected carrier gases are helium for gas species other than hydrogen, and nitrogen for the GCs monitoring for hydrogen.

3.3.4 FTIR Purge Gas Supply

The FTIR purge gas supply is also the high purity nitrogen carrier gas for the hydrogen detection GC and is provided by pressure regulator (PCV-*64). The bottles of high purity nitrogen are located in the gas bottle rack adjacent to the GCS building. The purging of the FTIR is performed in conjunction with the system manual calibration and provides a zero background reference for the FTIR system performance validation. The purge gas is isolated from the FTIR chamber through a single isolation valve (SV-*48). The FTIR chamber is purged by first isolating the sample gas inlet valve (SV-*40), and then alternately evacuating the chamber via the sample pump, and purging with the nitrogen bottle gas.

3.4 GCS POWER DISTRIBUTION

The GCS AC power is supplied from the 75 kVA 240/120 VAC single phase transformer located for the selected tank per the appropriate installation drawings. The AC power distribution within the GCS is defined on the system Electrical One-Line Diagram, H-14-100436. There is only one source of AC power to the GCS, but power conditioning is provided to support the GCS systems. Facility 240/120 VAC power supports the HVAC, lighting, gas sample pump, sample line heat trace, and convenience outlets. Conditioned power, provided by a noise reduction isolation transformer, provides power for all the analytical and process instrumentation including the computer systems and the 24 VDC power supply for the loop powered instruments and discrete contacts that interface the data system I/O cards.

3.4.1 Building AC Power Distribution

The GCS will be supplied 240/120 VAC single phase power to a 200 ampere distribution panel (DP-*10). The electrical one-line diagram, H-14-100436, defines the distribution from the main entrance panel, instrumentation isolation transformer, and other individual power loads.

Unconditioned power is supplied to the following:

- Interior lights and receptacles.
- Exterior lighting and GFI receptacles.
- HVAC.
- Sample line trace heat.
- 7.5 kW stepdown isolation transformer
- GCS sample pump

3.4.2 Conditioned AC Power Distribution

Conditioned AC power in the GCS is provided through an instrumentation isolation transformer. The isolation transformer provides power for all the facility analytical and process instrumentation.

3.4.3 Instrumentation DC Power Distribution

The instrumentation DC power supply (PS-*10) provides a maximum of 2 amperes at 24 VDC for loop powered process instrumentation and process alarm contact interface into the A/D and digital I/O cards located in the GCS data system.

3.5 HEAT TRACE AND ENVIRONMENTAL CONTROL

The GCS must operate during all seasons on the selected tank farm without additional environmental protection. It is a requirement that the system provide the gas sample to the analytical equipment without being condensed in the delivery tubing. Sample tube heat trace is designed to provide a dry sample to the analytical equipment over the expected exterior ambient temperature range. Since the analytical equipment must be able to perform during wide outside ambient temperature conditions, an insulated building with an HVAC system has been utilized to house the instrumentation.

3.5.1 Sample Gas Line Heat Trace Control and Monitoring

Between the exhaust header and the GCS instrumentation, the main sample gas line utilizes prefabricated heat traced and insulated 1.27 cm (1/2 inch) stainless steel tubing. The tubing is insulated and is heat traced at 0.33 Watt/cm (10 watts per foot). The analysis in Appendix A of WHC-SD-WM-SDD-001, *Standard Hydrogen Monitor System Design Description*, shows that the heat trace will raise the sample gas to an operating temperature of 21 °C (70 °F) in 457.2 cm (15 feet) of tubing at a sample flow of 0.71 SL/s (1.5 SCFM) at a worst case sample gas temperature of -1 °C (30 °F) and ambient temperature of -29 °C (-20 °F). It is assumed that the dew point of the sample gas on the warmest day would not exceed 21 °C (70 °F).

The heat trace controller (TIC-*10) provides a local digital temperature display and is configured for ON/OFF control with a minimum deadband of 2 °F. The controller's second setpoint (TSL-*10) will provide low temperature alarm contacts to be interfaced to the GCS data system. The temperature feedback is provided through a single type K thermocouple (TE-*10) that is nominally located 122 cm (4 ft) upstream of the sample gas entrance into the GCS building. The GCS HVAC will maintain the sample temperature while in the building and the additional heat trace between the GCS building, sample pump and the exhaust duct supply or return port will provide adequate additional heating to maintain the sample gas above dew point.

3.5.2 Building HVAC Control and Monitoring

The GCS building is equipped with an HVAC unit (ACU-*10) which provides cooling in the summer and heating in the winter. The HVAC unit is equipped with a thermostat for controlling the desired temperature. Room ambient temperature monitoring, display and transmission will be provided by an RTD (TE-*11) and signal conditioner with a local digital readout (TIT-*11) and a 4-20 mA analog output to interface the GCS data system I/O to provide remote temperature logging. The accuracy of the RTD is ±0.15% +0.002 X °C (actual temperature). The accuracy of the readout transmitter is ±0.2°C ± ½ LSD.

4.0 SYSTEM LIMITATIONS AND RESPONSE TO CASUALTY EVENTS

The gas monitoring system contains the sampled gas in stainless steel for the duration of its path outside the tank vapor space. The sampling system uses a vacuum pump to draw the gas from the tank exhaust duct and return it to the common AN-105 and AW-101 tank vent header. The entire system is under a vacuum as provided by the tank ventilation system and the sampling system. These two barriers, the stainless steel and vacuum, provide the containment for the monitoring system sample gas. The following paragraphs identify postulated system limitations and casualty events and potential responses.

4.1 BREACH OF SAMPLING SYSTEM CONTAINMENT

The failure of the sampling system stainless steel containment components would provide a path to atmosphere. Since the system will be initially leak checked with pressure, and routinely checked during its operational life, the only credible path to atmosphere would be from an improper valve operation.

The result of an open valve upstream of the sample pump would be to allow inflow of atmosphere to dilute the sample gas providing erroneous data from the analytical instruments. This will be managed administratively.

The result of a disconnected or broken sample return line downstream of the sample pump would result in waste tank vapor being vented directly to atmosphere. Although this would be undesirable, the sample stream inlet to the GCS is filtered through two 0.2 micron particulate filters connected in series which removes smaller particle sizes and is more efficient than the exhaust duct HEPA filter system. This will be managed administratively.

4.2 TOTAL LOSS OF FACILITY POWER

Total loss of facility power will terminate the sampling system operation. Gas monitoring will be suspended until power is restored.

4.3 SAMPLE PUMP FAILURE

Sample pump failure will terminate the sampling system flow. The sample flow process signal to the GCS data system will provide the operator a low flow indication of pump failure. The gas monitoring will be suspended until the pump operation is restored.

4.4 LOSS OF FACILITY HVAC

Loss of facility HVAC will affect the quality of the analytical system data. A prolonged outage may require the system equipment power to be removed. The operation of the gas monitoring system will be administratively controlled during loss of HVAC.

5.0 OPERATION

The operation of the GCS will permit the continual sampling and monitoring of the waste tank gases. Accurate gas analysis will allow determination of the actual lower flammability limit of the selected tanks, accurately measure low baseline gas release concentrations, and determine potential hazards associated with larger Gas Release Events.

5.1 SYSTEM STARTUP

The system startup is a major evolution in the system operation. Startup is composed of many administratively and procedurally controlled subtasks. The following provides a proposed sequence of events for those subtasks. (It should be noted that a functional leak check may be performed at any time following system energization.)

5.1.1 Verify that the facility system power is available.

5.1.2 Energize the HVAC system and establish the facility environmental control to 24 ± 3 °C (75±5 °F).

5.1.3 Verify the position of all the manual valves.

5.1.4 Energize each of the powered instruments and verify nominal indications.

5.1.5 Adjust the sample gas heat trace control. Energize the heat trace power and verify that the sample line is controlling to setpoint.

5.1.6 Verify that the manual sample line valves are properly positioned and start the sample pump. (Should be performed in conjunction with the associated SHMS sample line flow.)

5.1.7 Adjust the main sample flow control valve (SV-*13) for the required flow. Verify the following sample flow parameters are acceptable:

- Proper flow indication on FIT-*10.
- Proper range of sample line absolute pressure as indicated on PIT-*10 and PIT-*40.
- Proper differential pressure indicated across the inlet filter as indicated on PDI-*10.
- Proper temperature indication on the FTIR gas temperature indicating transmitter TIT-*40.

5.1.8 Adjust the appropriate carrier gas bottle pressures for each of the dual column GCs.

5.1.9 Establish the sample gas flows in each of the GCs using the appropriate flow indicator and integral flow control valve. Verify the following parameters are acceptable.

- GC differential pressure is indicating within bounds.

- GC inlet pressure is indicating within bounds.

5.1.10 Adjust the automatic calibration gas bottle pressures and gas flows for each of the GC columns.

5.1.11 Verify that the process and analytical instrumentation signals are being transmitted and received by the GCS data system.

5.2 PERFORM A FUNCTIONAL VALIDATION ON EACH GAS CHROMATOGRAPH

The two dual column GCs will require a functional validation on a routine basis. The procedure may require Maintenance, Operations and laboratory support personnel. The manually installed, portable calibration gas bottles will be used to inject standard gases at a selected pressure for this validation. It will be important to follow the validation procedures closely to assure consistent results from the equipment.

5.3 PERFORM A FUNCTIONAL VALIDATION ON THE FTIR

The FTIR will require a functional validation on a routine basis. The procedure may require Maintenance, Operations and laboratory support personnel. The manually installed, portable calibration gas bottles will be used to inject standard gases at a selected pressure for this validation. It will be important to follow the validation plan closely to assure consistent results from the equipment. The data will be compared to a HITRAN spectral library data base for validation.

5.4 PERFORM A ROUTINE SYSTEM LEAK CHECK

It will be necessary to perform a routine system leak check, especially after any sample loop components have been removed or replaced. The leak check will utilize the sample pump to generate the vacuum, and the system absolute pressure gauges will provide the indication for leak evaluation. If the system is found to have a leak, portions of the system will be isolated until the leak can be identified and corrected.

6.0 MAINTENANCE

The GCS including the facility support equipment, gas sample delivery system, analytical instrumentation, and data processing and transmission equipment will require routine maintenance to support continual operation. Detailed maintenance procedures will cover the general maintenance activities. Some of the maintenance activities, such as the calibration of the GCs and FTIR, will be performed by laboratory support, Operations, and Maintenance personnel. The following is a general listing of maintenance operations.

6.1 Manual calibration of each gas chromatograph system using standard gases (NT-*20, NT-*30).

6.2 Manual validation of the FTIR spectrometer system using standard gases, with the results compared to the HITRAN data base (NT-*40).

6.3 Calibration of the gas sample inlet absolute pressure transmitter (PIT-*10).

6.4 Calibration of the input filter differential pressure gauge (PDI-*10).

6.5 Calibration of each GC differential pressure transmitter (PDIT-*20, PDIT-*30).

6.6 Calibration of the FTIR absolute pressure transmitter (PIT-*40).

6.7 Calibration of the FTIR temperature readout and transmitter (TIT-*40).

6.8 Calibration of the main sample flow differential pressure transmitter (FIT-*10).

6.9 Calibration/verification of the gas sample line heat trace control, readout, and low temperature alarm (TIC-*10, TSL-*10).

6.10 Calibration of the facility temperature readout and transmitter (TIT-*11).

6.11 Functional verification of each GC sample gas flow indicator (FI-*20, FI-*30).

6.12 Functional verification of the electrically operated calibration gas isolation valves (SOV-*20, SOV-*30).

6.13 Draining of or replacement of any sample line input filters.

6.14 Replacement or cleaning of the air conditioner evaporator cooling air filter. General HVAC preventative maintenance.

6.15 Routine replacement of carrier and calibration gas bottles.

6.16 Routinely, as required, bake out the GC columns and re-establish proper analytical methods.

7.0 REFERENCES

7.1 GENERAL GOVERNMENT AND REGULATORY DOCUMENTS

7.1.1 DOE Order 6430.1a, "General Design Criteria".

7.1.2 NFPA-70, "National Electrical Code • 1993".

7.2 HANFORD GENERATED ENGINEERING DOCUMENTS

7.2.1 WHC-SD-WM-ETP-143, *TWRS Hydrogen Mitigation Gas Characterization System Design and Fabrication Task Plan*.

7.2.2 WHC-SD-WM-SDD-003, *Waste Tank 241-SY-101 Gas Monitoring System 2 System Design Description*.

7.2.3 WHC-SD-WM-DA-085, *241-SY-101 Gas Monitoring System Design Support*.

7.2.4 WHC-SD-WM-FDC-041, *Gas Characterization System Functional Design Criteria*.

APPENDIX A - GCS DRAWING/SUPPORTING DOCUMENT LIST

GCS DRAWING LIST

DRAWING NO.	TITLE
H-2-818214	STANDARD-B HYDROGEN MONITORING SYSTEM GAS BOTTLE RACK
H-2-818220	STANDARD-B HYDROGEN MONITORING SYSTEM SAMPLE PUMP STAND ASSY
H-14-100434	WASTE TANK GAS CHARACTERIZATION SYS. DRAWING TREE & INDEX
H-14-100435	WASTE TANK GAS CHARACTERIZATION SYS. PIPING & INSTR DIAGRAM
H-14-100436	WASTE TANK GAS CHARACTERIZATION SYSTEM ONE-LINE DIAGRAM
H-14-100437	WASTE TANK GAS CHARACTERIZATION SYSTEM ELEMENTARY DIAGRAM
H-14-100438	WASTE TANK GAS CHARACTERIZATION SYSTEM ASSEMBLY
H-14-100439	WASTE TANK GAS CHARACTERIZATION SYSTEM INSTR/VALVE PANEL ASSEMBLY
H-14-100440	WASTE TANK GAS CHARACTERIZATION SYSTEM GC CABINET ASSEMBLY
H-14-100441	WASTE TANK GAS CHARACTERIZATION SYSTEM COMPUTER CABINET ASSEMBLY
H-14-100442	WASTE TANK GAS CHARACTERIZATION SYSTEM JUNCTION BOX ASSEMBLY
H-14-100443	WASTE TANK GAS CHARACTERIZATION SYSTEM WIRING DIAGRAM
H-14-100444	WASTE TANK GAS CHARACTERIZATION SYSTEM GC CABINET WIRING DIAGRAM
H-14-100445	WASTE TANK GAS CHARACTERIZATION SYSTEM COMPUTER CABINET WIRING DIAGRAM
H-14-100446	WASTE TANK GAS CHARACTERIZATION SYSTEM LOOP DIAGRAMS
H-14-100447	WASTE TANK GAS CHARACTERIZATION SYSTEM INTERCONNECTION DIAGRAM
H-14-100448	WASTE TANK GAS CHARACTERIZATION INSTALLATION
H-14-100449	AN FARM WASTE TANK GAS CHARACTERIZATION INSTALLATION

APPENDIX A (continued) - GCS DRAWING/SUPPORTING DOCUMENT LIST

GCS SUPPORTING DOCUMENT LIST

DOCUMENT NO.	TITLE
WHC-SD-WM-ETP-143,	*TWRS Hydrogen Mitigation Gas Characterization System Design and Fabrication Engineering Task Plan*
WHC-SD-WM-FDC-041,	*Gas Characterization System Functional Design Criteria*
WHC-SD-WM-ATP-160,	*Gas Characterization System Shop Acceptance Test Procedure*
WHC-SD-WM-ATR-160,	*Gas Characterization System Shop Acceptance Test Report*
WHC-SD-WM-ATP-161,	*Gas Characterization System 241-AN-105 Field Acceptance Test Procedure*
WHC-SD-WM-ATR-161,	*Gas Characterization System 241-AN-105 Field Acceptance Test Report*
WHC-SD-WM-ATP-162,	*Gas Characterization System 241-AW-101 Field Acceptance Test Procedure*
WHC-SD-WM-ATR-162,	*Gas Characterization System 241-AW-101 Field Acceptance Test Report*
WHC-SD-WM-ATP-172,	*Gas Characterization System Software Acceptance Test Procedure*
WHC-SD-WM-ATR-172,	*Gas Characterization System Software Acceptance Test Report*
WHC-SD-WM-SFR-012,	*Functional Requirements for Gas Characterization System Computer Software*
HNF-SD-WM-CSWD-077,	*Computer Systems and Software Description for Gas Characterization System*
VI-22665	System Certified Vendor Information

APPENDIX B - MAJOR COMPONENTS LIST

LIST OF COMPONENTS IN THE SAMPLE GAS STREAM:

COMPONENT	DESCRIPTION	VENDOR AND PART NO.
FE-*10	IN-LINE LAMINAR FLOW ELEMENT	MERIAM INSTRUMENT, 50MJ10-10
FI-*20	LOW FLOW METER	WALLACE AND TIERNAN, 30D016S1XXX
FI-*30	LOW FLOW METER	WALLACE AND TIERNAN, 30D016S1XXX
FIV-*50	LOW FLOW ROTAMETER	WALLACE AND TIERNAN, 32E113S1XX3
FIT-*10	DIFFERENTIAL PRESS. TRANSMITTER	ROSEMOUNT 3051CD-1A22A1A-B4-E5-M5
FLT-*10	25 MICRON FILTER	GENERANT, 2S500-25
FLT-*11	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T8FF
FLT-*12	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T8FF
FLT-*13	MOISTURE SEPARATOR	A+ CORP., 101-002-SS
FLT-*20	0.2 MICRON FILTER	NUPRO, SS-4FW-2
FLT-*21	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T4FF
FLT-*23	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T4FF
FLT-*30	0.2 MICRON FILTER	NUPRO, SS-4FW-2
FLT-*31	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T4FF
FLT-*40	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T4FF
FLT-*41	0.2 MICRON HI PURITY FILTER	MATHESON, 6134-T8FF
FLT-*50	FILTER	FISHERBRAND, 09-753-13C
NE-*40	FTIR SAMPLE CELL	INFRARED ANALYSIS, 10-PA WITH GOLD MIRRORS (mod. 5m)
NT-*20	GAS CHROMATOGRAPH	MICROSENSOR TECH. INC., M200D
NT-*30	GAS CHROMATOGRAPH	MICROSENSOR TECH. INC., M200D
P-*10	SAMPLE PUMP	PARKER HANNIFIN, MB-302-XP (29678M1)
PDI-*10	DIFFERENTIAL PRESSURE INDICATOR	ORANGE RESEARCH, 1516 DG-1 C-4.5L
PIT-*10	ABS. PRESS INDICATE TRANSMITTER	ROSEMONT, 3051CA-1A22A1A B4-E5-M5
PDIT-*20	DIFF.PRESS. INDICATE TRANSMITTER	ROSEMONT, 3051CD-2A22A1A B4-E5-M5
PDIT-*30	DIFF.PRESS. INDICATE TRANSMITTER	ROSEMONT, 3051CD-2A22A1A B4-E5-M5
PIT-*40	ABS. PRESS INDICATE TRANSMITTER	ROSEMONT, 3051CA-1A22A1A B4-E5-M5
PRV-*40	1/4" ADJ. PRESS. RELIEF VALVE	NUPRO, SS-4-CPA-2-3
SOV-*21	3 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B14DK1075-110VAC
SOV-*22	3 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B14DK1075-12VDC
SOV-*31	3 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B14DK1075-110VAC
SOV-*32	3 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B14DK1075-12VDC
SV-*01	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*03	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*04	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*05	1/4" FILTER DRAIN VALVE	WHITEY, SS-42S4
SV-*06	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*07	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*08	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*09	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*10	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*11	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*12	1/2" SS BALL VALVE	WHITEY, SS-63TS8

LIST OF COMPONENTS IN THE SAMPLE GAS STREAM:(CONT.)

COMPONENT	DESCRIPTION	VENDOR AND PART NO.
SV-*13	1/2" BONNET FLOW CONT. VALVE	WHITEY, SS-12NKRS8
SV-*14	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*15	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*16	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*17	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*18	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*19	1/2" CHECK VALVE	CIRCLE SEALS CONT., 3008S00T-0.15
SV-*20	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*21	1/8" METERING VALVE	NUPRO, SS-SS2
SV-*22	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*23	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*24	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*25	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*26	1/8" METERING VALVE	NUPRO, SS-SS2
SV-*27	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*30	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*31	1/8" METERING VALVE	NUPRO, SS-SS2
SV-*32	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*33	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*34	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*35	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*36	1/8" METERING VALVE	NUPRO, SS-SS2
SV-*37	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*40	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*41	1/2" SS BALL VALVE	WHITEY, SS-63TS8
SV-*42	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*43	1/8" SS BALL VALVE	WHITEY, SS-41S2
SV-*50	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*51	1/4" SS BALL VALVE	WHITEY, SS-62TS4
TE-*40	TEMPERATURE ELEMENT	WATLOW/GORDON, RFHLOTK100CA200

LIST OF COMPONENTS NOT IN THE SAMPLE GAS STREAM:

ACU-*10	HVAC UNIT	ENCLOSURE
DP-*10	POWER PANEL BOARD (120//240 VAC)	ENCLOSURE
FIV-*20	LOW FLOW ROTAMETER	WALLACE AND TIERNAN, 32E083S1XX2
FIV-*30	LOW FLOW ROTAMETER	WALLACE AND TIERNAN, 32E083S1XX2
FLT-*60	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
FLT-*61	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
FLT-*62	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
FLT-*63	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
FLT-*65	2 MICRON INLINE FILTER	NUPRO, SS-4FW-2
FLT-*69	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
HT-*10	SAMPLE GAS LINE HEAT TRACE	O'BRIEN, TPE2-B4-B10 (TPE1-B4-B10)
JBX-*10	JUNCTION BOX ASSEMBLY	ENCLOSURE
JY-*10	SOLID STATE RELAY	POTTER & BRUMFIELD, SSRT-240D25
JY-*20	SOLID STATE RELAY	POTTER & BRUMFIELD, SSRT-240D25
JY-*30	SOLID STATE RELAY	POTTER & BRUMFIELD, SSRT-240D25
MUX-*10	MULTIPLEXER AMUX-64T	NATIONAL INSTRUMENTS, 776366-90
NT-*40	FTIR OPTICAL UNIT/PWR SUPPLY	BIORAD, FTS 175/013-4434
PC-*10	HOST COMPUTER SYSTEM	INTEL 586 (min.)
WITH	ANALOG I/O, AT-MIO-16	NATIONAL INSTRUMENTS, 776578-11
WITH	DIGITAL I/O, PC-DIO-24	NATIONAL INSTRUMENTS, 776247-01
PC-*20	NIT-*20 PERSONAL COMPUTER	INTEL 486/33 (min.)
PC-*30	NIT-*30 PERSONAL COMPUTER	INTEL 486/33 (min.)
PC-*40	NIT-*40 PERSONAL COMPUTER	INTEL 486/33 (min.)
PCV/PI-*60	LOW PRESS. REGULATOR/GAGE	MATHESON 3122-580
PCV/PI-*61	H2 LOW PRESS. REGULATOR/GAGE	MATHESON 3813-350
PCV/PI-*62	LOW PRESS. REGULATOR/GAGE	MATHESON 3122-580
PCV/PI-*63	CH4 LOW PRESS. REGULATOR/GAGE	MATHESON 3813-350
PCV/PI-*64	SINGLE STAGE REGULATOR	MATHESON 3421
PCV/PI-*65	DUAL STAGE REGULATOR	MATHESON 3813
PS-*10	24 VOLT DC POWER SUPPLY	ACOPIAN, A24MT210
SOV-*20	2 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B2DA1175-110VAC
SOV-*30	2 WAY SOLENOID VALVE	HONEYWELL/SKINNER, B2DA1175-110VAC
SV-*28	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*29	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*38	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*39	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*48	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*49	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*60	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*61	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*62	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*63	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*64	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*65	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*66	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*67	1/4" SS BALL VALVE	WHITEY, SS-62TS4
SV-*69	1/4" SS BALL VALVE	WHITEY, SS-62TS4

<u>LIST OF COMPONENTS NOT IN THE SAMPLE GAS STREAM:</u> (continued)

TE-*10	TEMPERATURE ELEMENT TYPE K T/C	GORDON, 1AFECOTF720UK300
TE-*11	TEMPERATURE ELEMENT	WATLOW/GORDON, RFHLOTK100CA200
TIC-*10	TEMP.INDICATE CONTROL/ALARM	OMEGA, CN9121A
TIT-*11	TEMP.INDICATE TRANSMITTER	NEWPORT, INFU-0-0-1-0-DC1
TIT-*40	TEMP.INDICATE TRANSMITTER	NEWPORT, INFU-0-0-1-0-DC1
TSL-*10	HT TEMP ALARM SWITCH- LOW	PART OF TIC-*10
YY-*10	INPUT MODULE SSR-IDC-5	NATIONAL INSTRUMENTS, 776239-01
WITH	OUTPUT MODULE SSR-ODC-5	NATIONAL INSTRUMENTS, 776241-01
WITH	SIGNAL CONDITIONING	NATIONAL INSTRUMENTS, 776290-916

APPENDIX C - Gas Sample Delivery Speed Calculations

These calculations were performed to determine the time it takes for a gas sample to travel from the exhaust header to a gas chromatograph sensing element. The original calculation was done for the GMS 2 system and was included in WHC-SD-WM-SDD-003, *Waste Tank 241-SY-101 Gas Monitoring System 2 System Design Description*, Appendix B. Since the GCS systems will be installed in different tank farms and at different distances from the tank exhaust header, the analysis has been updated and included in this document so the exact time delay for a gas sample delivery can be calculated for each GCS installation. This appendix consists of 7 pages including this page.

DESIGN CALCULATIONS

(1) Drawing H-14-100438 (2) Doc. No. ______ (3) Page 1 of 5
(4) Building East Tank Farms (5) Rev. ______ (6) Job No. ______
(7) Subject Gas Characterization System Sample Gas Delivery Velocity and Time
(8) Originator T C Schneider [signature] Date 7-8-98
(9) Checker B L Philipp [signature] Date 07/07/98

Calculate typical sample gas velocities and gas delivery times for the Gas Characterization System (GCS) sample transport system.

Assumptions:

1. 0.5 inch OD, 0.049 inch wall Stainless Steel tubing between the ventilation exhaust header and the GCS enclosure.

2. 0.5 inch OD, 0.049 inch wall Stainless Steel tubing sample delivery to the moisture filter inside the GCS enclosure.

3. 0.125 inch OD, 0.028 inch wall Stainless Steel tubing between the moisture filter and the gas chromatograph (GC) cabinet bulkhead connectors.

4. 0.0625 inch OD, 0.016 inch wall Stainless Steel tubing between the cabinet bulkhead connectors and the GC sample volumes.

5. Flow rate between the exhaust header and the GCS is nominally 0.5 cfm.

6. Flow rate in the GCS sample header is 0.5 cfm.

7. Flow rate in the individual GC sample lines is 10 cc/min.

8. The flow is based upon standard temperature and pressure.

9. 1728 in^3/ft^3

10. 2.5417 cm/in

DESIGN CALCULATIONS

(1) Drawing H-14-100438 (2) Doc. No. ______ (3) Page 2 of 5
(4) Building East Tank Farms (5) Rev. ______ (6) Job No. ______
(7) Subject Gas Characterization System Sample Gas Delivery Velocity and Time
(8) Originator T C Schneider [signature] Date 7-8-98
(9) Checker BL Philipp [signature] Date 07/07/98

Calculations:

I. Calculate the velocity of gas in the 1/2 inch tube at 0.5 cfm.

A. Calculate the volume of gas in one linear foot of 0.5 inch diameter tubing.

OD = 0.50 inch
Wall = 0.049 inch
ID = 0.402 inch

Area:

$\pi r^2 = 0.1269\ in^2$

Volume in one linear foot of tubing:

$0.1269\ in^2 \times 12\ in/ft = 1.523\ in^3/ft$

B. Calculate the length of 1/2 inch tubing needed to contain one ft^3 of gas.

$$\frac{1728 inch^3/ft^3}{1.523 inch^3/ft} = 1134.6 ft/ft^3$$

C. Calculate the gas velocity at the flow rate of 0.5 cfm.

$1134.6\ ft/ft^3 \times 0.5\ ft^3/min = 567.3\ ft/min$

$$\frac{567.3 ft/min}{60 sec/min} = 9.455 ft/sec$$

DESIGN CALCULATIONS

(1) Drawing H-14-100438 (2) Doc. No. ______ (3) Page 3 of 5
(4) Building East Tank Farms (5) Rev. ______ (6) Job No. ______
(7) Subject Gas Characterization System Sample Gas Delivery Velocity and Time
(8) Originator T C Schneider [signature] Date 7-8-98
(9) Checker BL Philipp [signature] Date 07/07/98

II. Calculate the velocity of gas in the 1/8 inch tube at the flow rate of 10 cc/min.

A. Calculate the volume (cc) of gas in one linear inch of 0.125 inch diameter tubing.

OD = 0.125 inch
Wall = 0.028 inch
ID = 0.069 inch = 0.175 cm

Area:

$\pi r^2 = 0.024 \text{ cm}^2$

Volume in one linear inch of tubing:

$0.024 \text{ cm}^2 \times 2.5417 \text{ cm/inch} = 0.061 \text{ cm}^3\text{/inch}$

B. Calculate the length of 1/8 inch tubing required to contain 1 cc of gas.

$$\frac{1}{0.061\,cc/inch} = 16.39\,inch/cc$$

C. Calculate the gas velocity at a flow rate of 10 cc/min.

$$16.39\,inch/cc \times 10\,cc/\text{min} = \frac{163.9\,inch/\text{min}}{60\text{sec/min}} = 2.732\,inch/\text{sec}$$

DESIGN CALCULATIONS

(1) Drawing H-14-100438 (2) Doc. No. ______ (3) Page 4 of 5
(4) Building East Tank Farms (5) Rev. ______ (6) Job No. ______
(7) Subject Gas Characterization System, Sample Gas Delivery Velocity and Time
(8) Originator T C Schneider TCSchneider Date 7-8-98
(9) Checker B L Philipp BL Philipp Date 07/07/98

III. Calculate the velocity of gas in the 1/16 inch tube at the flow rate of 10 cc/min.

A. Calculate the volume of gas in one linear inch of 0.0625 inch diameter tubing.

OD = 0.0625 inch
Wall = 0.016 inch
ID = 0.0305 inch = 0.0775 cm

Area:

$\pi r^2 = 0.00472\ cm^2$

Volume in one linear inch:

$0.00472\ cm^2 \times 2.5417\ cm/inch = 0.012\ cc/inch$

B. Calculate the length of 1/16 inch tubing required to contain one cc of gas.

$$\frac{1}{0.012\,cc/inch} = 83.3\,inch/cc$$

C. Calculate the gas velocity at a flow rate of 10 cc/min.

$$83.3\,inch/cc \times 10\,cc/\min = \frac{833\,inch/\min}{60\sec/\min} = 13.88\,inch/\sec$$

DESIGN CALCULATIONS

(1) Drawing H-14-100438 (2) Doc. No. ______ (3) Page 5 of 5
(4) Building East Tank Farms (5) Rev. ______ (6) Job No. ______
(7) Subject Gas Characterization System Sample Gas Delivery Velocity and Time
(8) Originator T C Schneider [signature] Date 7-8-98
(9) Checker BL Philips [signature] Date 07/07/98

IV. Calculate the sample delivery times using the nominal tubing lengths given the sample flow rates of 0.5 cfm and 10 cc/min.

A. Exhaust duct to GCS inlet = 75 feet (1/2 inch tubing)
B. GCS inlet to GC moisture filter = 8 feet (1/2 inch tubing)
C. GC inlet moisture filter to GC cabinet bulkhead = 86 inches (1/8 inch tubing)
D. CG cabinet bulkhead to GC sample volume = 10 feet (1/16 inch tubing)

A. 0.5 cfm

$$\frac{75ft}{9.455ft/sec}=7.93sec$$

B. 0.5 cfm

$$\frac{8ft}{9.455ft/sec}=0.846sec$$

C. 10 cc/sec

$$\frac{86inch}{2.732inch/sec}=31.48sec$$

D. 10 cc/sec

$$\frac{120inch}{13.88inch/sec}=8.65sec$$

Total sample delivery time = 48.91 sec (0.815 min)

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: Design Calculations for Gas Characterization System Sample Gas Delivery Velocity and Time

Author: T. C. Schneider

Yes	No	N/A	
[x]	[ ]	[ ]	Problem completely defined?
[x]	[ ]	[ ]	Necessary assumptions explicitly stated and supported?
[ ]	[ ]	[x]	Computer codes and data files documented?
[x]	[ ]	[ ]	Data used in calculations explicitly stated in document?
[x]	[ ]	[ ]	Data checked for consistency with original source information as applicable?
[x]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results?
[ ]	[ ]	[x]	Models appropriate and used within range of validity or use outside range of established validity justified?
[x]	[ ]	[ ]	Hand calculations checked for errors?
[ ]	[ ]	[x]	Code run streams correct and consistent with analysis documentation?
[ ]	[ ]	[x]	Code output consistent with input and with results reported in analysis documentation?
[ ]	[ ]	[x]	Acceptability limits on analytical results applicable and supported? Limits checked against sources?
[x]	[ ]	[ ]	Safety margins consistent with good engineering practices?
[x]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits?
[x]	[ ]	[ ]	Results and conclusions address all points required in the problem stated?

B L Philipp   B L Philipp
Reviewer

July 7, 1998
Date

APPENDIX D - HVAC Analysis for GCS

This appendix addresses the design analysis of the HVAC system for the GCS (GMS 2) building, refer to WHC-SD-WM-SDD-003, *Waste Tank 241-SY-101 Gas Monitoring System 2 System Design Description, Appendix C, HVAC Analysis for GMS 2*. Since the same enclosure and environmental requirements are specified for the GCS, the GMS 2 analysis should be applicable to the GCS.

The assumptions and heat load summary for GMS 2 is repeated here, and the heat load for the GCS is given for comparison and to show the heat load reserve for future equipment.

GMS 2 - HVAC Electrical Heat Loads

GENERAL DESIGN DATA

* Design Conditions:	Summer:	38°C (101° FDB), 20°C (68° FWB)
	Winter:	-13°C (9° FDB)
	Wind:	24 km/hr (15 mph)
* Indoor Design Temperature:		24 ± 3°C (75±5 °FDB)

ASSUMPTIONS

* No air infiltration or exfiltration
* Equipment runs continuously and is in operation simultaneously
* UPS and Isolation transformers are 85% efficient (generate 15% of their operating load as heat).

GMS 2 Internal Heat Sources

I. UPS Load Power

QTY	Description	V/Hz/Ph	A/ea	VA
1	CPU (GC System)	120/60/1	1.83	220
1	Monitor (GC System)	120/60/1	1.5	180
1	Bernoulli disk (GC System)	120/60/1	1.0	144
1	LabNet Power Supply (GC System)	120/60/1	0.25	30
1	CPU (FTIR System)	120/60/1	2.0	220
1	Monitor (FTIR System)	120/60/1	1.5	180
1	Modem (FTIR System)	120/60/1	0.5	60
			TOTAL	1034

II. Isolation Transformer Load Power

QTY	Description	V/Hz/Ph	A/ea	VA
3	Gas Chromatographs (10 amps ea)	120/60/1	30.0	3600
3	GC Integrators (0.4 amps ea)	120/60/1	1.2	144
1	FTIR Spectrometer/Power Supply	120/60/1	8-10	1080 avg.
1	Current Loop Power Supply	120/60/1	2.0	240
			TOTAL	5134

III. Other Equipment Load Power

QTY	Description	V/Hz/Ph	A/ea	VA
1	FTIR Cooling Package	120/60/1	7.0	840
1	Air Dryer (Plug in Rcpt)	120/60/1	0.8	96
			TOTAL	936

IV. Additional Heat Sources

QTY	Description	V/Hz/Ph	A/ea	VA
2	40 watt Fluorescent Bulbs	120/60/1	0.34	80
1	UPS inefficiencies	1034*0.15 =	155	
1	Isolation Transformer inefficiencies	5134*0.15 =	925	
			TOTAL	1160

TOTAL INTERNAL HEAT GAIN = 1034 + 5134 + 936 + 1160 = 8264 VA (watts)
(8264 Watts)*(3.414 BTU/Hr/Watt) = 28,213 BTU/Hr

GCS - Internal Heat Sources

I. Isolation Transformer Load Power

QTY	Description	V/Hz/Ph	A/ea	VA
3	486DX2 66 CPU's (2.7 amps ea) (2 ea GC, 1 ea FTIR)	120/60/1	3*325	975
1	CPU (GCS Data System)	120/60/1	2.7	325
2	Dual Column GC's (0.4 amp ea)	120/60/1	2*50	100
1	Computer Monitor (15")	120/60/1	1.8	216
1	Computer Monitor (17")	120/60/1	2.6	312
1	Ink Jet Printer	120/60/1	1.0	120
1	FTIR Opt.Bch Power Supply	120/60/1	4.0	480
1	24Vdc Inst. Loop Power Supply	120/60/1	1.0	120
			TOTAL	2648

II. Additional Heat Sources

QTY	Description	V/Hz/Ph	A/ea	VA
2	40 watt Fluorescent Bulbs	120/60/1	0.34	80
1	Isolation Transformer inefficiencies	2648*0.15 =	397	
			TOTAL	477

TOTAL INTERNAL HEAT GAIN = 2648 + 477 = 3125 VA (watts)
(3125 Watts)*(3.414 BTU/Hr/Watt) = 10,669 BTU/Hr

NOTE: The GCS HVAC reserve will be approximately

8264 - 3125 = 5139 VA (Watts)

28,213 - 10,669 = 17,544 BTU/Hr

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