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**STANDARD-B. HYDROGEN MONITORING SYSTEM
SYSTEM DESIGN DESCRIPTION**

T. C. Schneider

December 1994

Westinghouse Hanford Company
TWRS Safety Special Projects

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STANDARD-B HYDROGEN MONITORING SYSTEM SYSTEM DESIGN DESCRIPTION

1.0 INTRODUCTION

1.1 Background

During most of the year, it is assumed that the vapor space in the 177 radioactive waste tanks on the Hanford Project site contain a uniform mixture of gasses. Several of these waste tanks (currently twenty five, 6 Double Shell Tanks and 19 Single Shell Tanks) were identified as having the potential for the buildup of gases to a flammable level. An active ventilation system in the Double Shell Tanks and a passive ventilation system in the Single Shell Tanks provides a method of expelling gasses from the tanks. A gas release from a tank causes a temporary rise in the tank pressure, and a potential for increased concentration of hydrogen gas in the vapor space. The gas is released via the ventilation systems until a uniform gas mixture in the vapor space is once again achieved. The SHMS is designed to monitor and quantify the percent hydrogen concentration during these potential gas releases.

1.2 Scope

This document describes the design of the Standard-B Hydrogen Monitoring System, (SHMS) and its components as it differs from the original SHMS. The differences are derived from changes made to improve the system performance but not implemented in all the installed enclosures.

Upon installing the original field design, it was determined that interfering gases rendered the solid state MOS ppm sensors useless during a gas release event. The MOS ppm sensors and signal conditioning was administratively removed/disabled from the installed SHMS enclosures. Since the initial installations occurred on waste tank 241-SY-101 where there were multiple analytical instruments measuring low concentration hydrogen gas, it was deemed unnecessary to modify the SHMS enclosures on 241-SY-101.

The SHMS is designed to analyze tank vapor space gases for specific ranges of hydrogen content at any of the radioactive hazardous waste tanks. The original SHMS design was implemented in 1992 and the monitor enclosures were sited on the SY-101 waste tank in support of the Hydrogen Mitigation Project. The analysis, components, drawings, and supporting documents used in the design of the first system are provided in WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992).

2.0 FUNCTION AND DESIGN REQUIREMENTS

The primary function of the Hydrogen Monitoring System is to monitor specifically for hydrogen in the waste tank atmosphere which may also contain (but not be limited to) unknown quantities of air, nitrous oxide (N_2O), ammonia (NH_3), water vapor, carbon dioxide (CO_2), carbon monoxide (CO) and other gaseous constituents. The hydrogen monitoring system consists of hydrogen specific monitors, a grab sampler to identify other gaseous constituents, and the gas sampling system (tubing, valving, vacuum pumps etc.) necessary to support the operation of the instrumentation. This system will be located in a local enclosure and shall be capable of interfacing to any radioactive hazardous waste tank. The specific system design requirements and criteria are provided in WHC-SD-WM-CR-043, *Design Requirements and Criteria for a Hydrogen Monitoring System for Tanks 103-SY and 104-AN* (Groth 1991). The system installation design requirements are provided in WHC-SD-WM-CR-053, *200 Area Hydrogen Watch List Waste Tank Standard Hydrogen Monitoring System Installation Design Criteria* (Schneider 1994)

3.0 DESIGN DESCRIPTION

The design modifications to the SHMS to provide the SHMS-B, included the removal of the solid state MOS sensors, the addition of a second Whittaker electrochemical sensor and associated signal conditioning and the addition of an automatic sample gas grab sampling feature. The second electrochemical cell will provide a low range hydrogen monitoring channel (0-1% by volume) as well as a proven, redundant, monitoring equipment. The automatic grab sampling feature will allow for the collection of vapor space gases released during an event without operator intervention.

Figure 1 is a block diagram of the SHMS-B system showing the principal system components and their respective positions in the system. The SHMS-B can be separated into a Controlled Environment System Enclosure, Sample Gas Transport System and the Gas Sampling and Analytical Instrumentation System.

The Controlled Environment System Enclosure provides a protected location for the gas sampling station and analytical instrumentation. When provided electrical utilities, the enclosure may be installed in an unsheltered area of the tank farms.

The Sample Gas Transport System is comprised of tubing, valves, filters, sensors, and other equipment necessary for the safe continuous analysis and collection of gas samples from within a tank vapor space. The sample gas is routed to the environmentally controlled enclosure.

The Gas Sampling and Analytical Instrumentation System is comprised of transmitters and alarms necessary for the local and remote recording of a gas release cycle and for the timely response by tank farm personnel to a gas release event. Included in this system are intrinsic safety barriers for

compliance with DOE ORDER 6430.1A and NFPA-70 for devices that come in contact with the sample stream from a Class I, Division 1, Group B environment. Also, the gas lines and enclosure are monitored for temperature, and temperature alarms are activated if necessary. Refer to Drawing H-2-817851, *Standard-B Hydrogen Monitoring System Piping and Instrumentation Diagram* for the layout of the gas sampling system and for the selection of equipment and instrumentation identifiers as specified in the "General Notes".

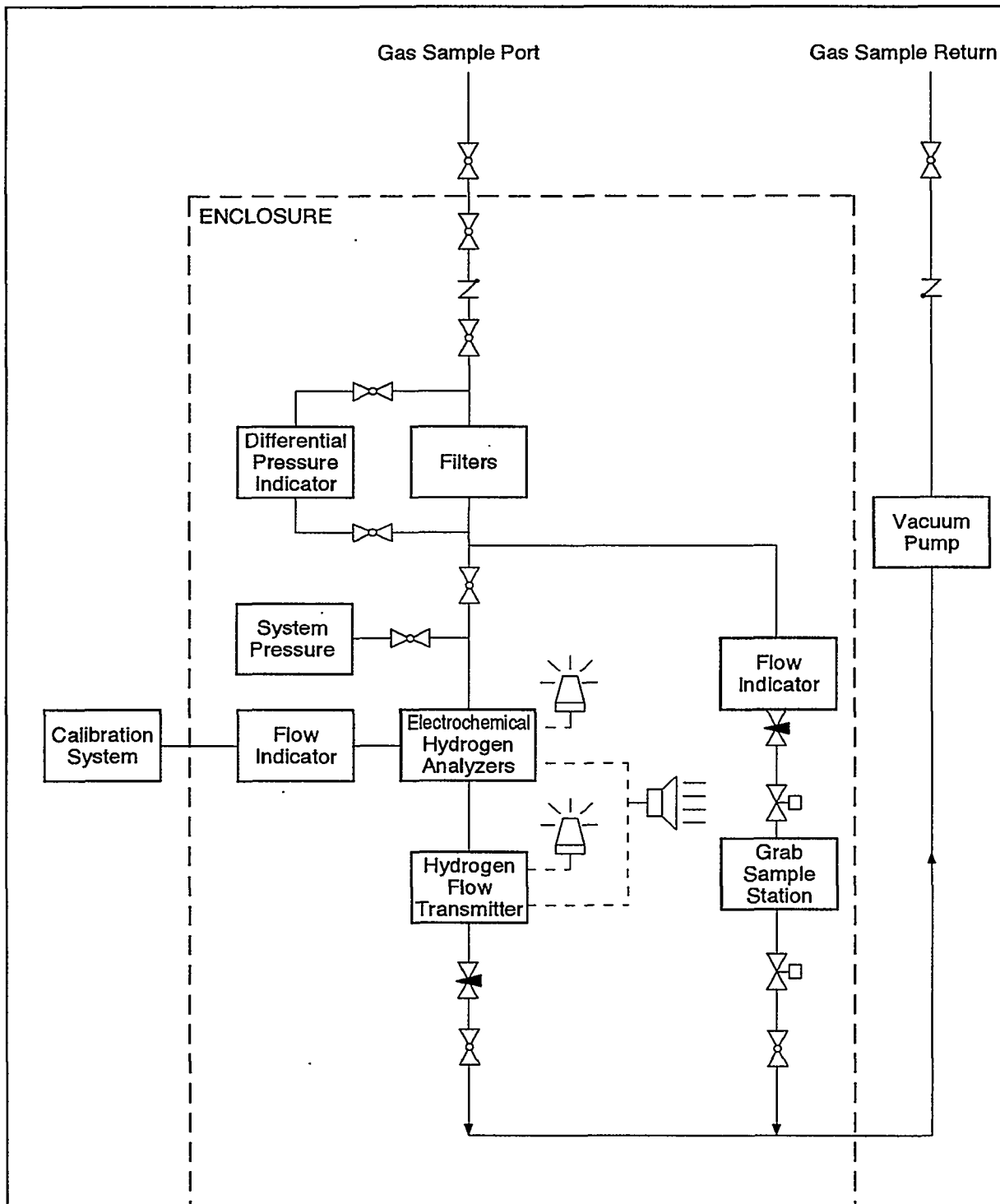


FIGURE 1
SYSTEM BLOCK DIAGRAM

3.1 Sample Gas Transport System

The sample gas transport system is designed to collect gas samples in an efficient and safe manner from within the tank vapor space via the tank ventilation exhaust header or tank riser. The sample stream is routed via stainless steel tubing to an environmentally controlled enclosure containing the analytical instruments and grab sample assembly necessary to monitor for hydrogen and other gaseous constituents.

Isolation valves are installed on both sides of all major system components to support system isolation, maintenance and trouble shooting. Back-flow preventers are placed in strategic locations to prevent the back-flow of gases into the tank and into the vacuum pump. The inlet back-flow preventer has been selected to prevent the propagation of a flame front and thus provide extra protection for the tank vapor space, even though no ignition sources exist in the sampling system.

Before the sample gas is allowed to flow to the instruments it is filtered to remove potentially contaminated particulates. Differential pressure indication is provided across the filters to monitor for plugging.

The rest of the SHMS Sample Gas Transport System can be defined as loops in which gas samples are collected from the tank, routed through hydrogen detection sensors and returned to the tank. The following paragraphs give a general description of each loop:

The Sample Main Flow Loop utilizes two electrochemical cells for percent concentration hydrogen monitoring. The sample line pressure is locally indicated and the sample gas flow is monitored and alarmed. The sample flow is controlled by means of a manual sample flow control valve.

The Gas Grab Sampling Loop provides a method for collecting gas samples in cylinders for lab analysis of other gas species besides hydrogen. The grab samples can be taken automatically when the hydrogen concentration exceeds a preset value, or by operator intervention at any time desired.

Hydrogen monitoring must always utilize the sample main flow loop. The grab sample loop can be operated separately or in conjunction with the sample main flow loop. The two loops merge to a single return line. This provides a single point for returning sample gasses to the tank ventilation system for release to the atmosphere through the HEPA filters. A sampling vacuum pump is located downstream of all instruments, holding the sample lines within the instrument enclosure below atmospheric pressure. Consequently, gas leaks out of the sample lines and into the enclosure cannot occur during normal operation. All of the enclosure tubing is leak checked prior to field operation and following removal and replacement of sample stream components.

3.1.1 System Tubing

Stainless steel tubing is used throughout the gas sampling system. Stainless steel was selected for its ability to withstand a wide range of temperature and condensed vapors considered to have a pH from 8 to 12. The sample tubing provides a physical safety barrier between the gas sample stream and apparatus not qualified as intrinsically safe. Tubing of the appropriate size and wall thickness was selected to minimize flow induced pressure drops in the sample stream.

3.1.2 System Isolation Valves

Isolation valves are installed on both sides of all major system components to support system maintenance and trouble shooting. These isolation valves were selected for their compensating seat design that ensures leak-tight sealing and their bottom loaded stems that prevent stem blowouts for enhanced system safety.

3.1.3 Sample Inlet Back-flow Preventer

Located between the filters and where the sample gas line enters the enclosure is a sample inlet back-flow preventer (BFP-*--1-1) used to prevent the back flow of gas into the tank. Although no ignition sources are known to exist in the sampling system, the back-flow preventer (BFP) has been selected to mitigate the propagation of a flame front into the tank vapor space in the unlikely event that the gas line is ignited. The BFP is made of 303 stainless steel. Seat material is Viton A and the operating temperature of the valves is -29°C to 204°C (-20°F to 400°F). Cracking pressure is specified at 1.03 kPa (0.15 psi). The BFPs are considered to meet the ISA RP12.6 criteria for "Simple Apparatus" which is intrinsically safe due to the construction materials.

3.1.4 Sample Inlet Filter System

The enclosure contains, in series, one 25 micron filter within a moisture separator and two 0.2 micron filters which remove particulates from the sample gas before it is allowed to flow to the sensors.

3.1.4.1 25 Micron Filter

The 25 micron filter (F-*--1-1) is a self-cleaning type used to remove water and particulate matter such as dirt and pipe scale from the gas sample entering the SHMS. The contaminants in the sample gas are trapped in a curved baffle in the filter assembly and collected at the bottom of a Lexan transparent bowl to provide a visual indication of the water level and

contaminants. Controlled draining of the bowl is through a manually operated ball valve (MV-*-1-5) at the bottom of the bowl.

3.1.4.2 0.2 Micron Filters

The 0.2 micron filters (F-*-1-2/3) are used to provide an extra measure of filtration for the sensors. They are rated 99.9% efficient at up to 6.61 L/Sec. (14.0 CFM). In comparison, the HEPA filters on the tank exhaust duct are 99.97% efficient at 0.3 microns. These filters utilize a microporous fiberglass media, molded with an acrylic binder and supported by a perforated 316 stainless steel screen and are compatible with a wide range of gasses. The operating temperature range is from -18°C to 74°C (0°F to 165°F).

3.1.4.3 Filter Differential Pressure Indicator

A differential pressure indicator (PDI-*-4-1) is installed across the filters to provide guidance on when to maintain the filters. When a pressure drop of 13.7 kPa (55" H₂O) or greater is indicated across the filters, the filter elements should be replaced to minimize the potential migration of contaminants 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" H₂O). The accuracy is ±2% (ascending).

3.1.5 Sample Main Flow Loop

The sample main flow loop provides primary monitoring for hydrogen. The hydrogen sensors used (NE-*-6/12-1) are electrochemical cells that provide an electrical signal proportional to the hydrogen partial pressure in the gas sample.

A pressure indicator (PI-*-8-1) provides a visual display of the sample line pressure for system flow calculations and a troubleshooting aid.

The main loop flow is continuously monitored. The sample gas flow monitoring system consists of an in-line laminar flow element (FE-*-7-1) and a differential pressure transmitter (FIT-*-7-1) located on the hydrogen sample gas line. As the sample gas flows through the flow element, the transmitter generates a 4-20 milliamp signal proportional to the gas flow rate.

The flow through the sample main flow loop can be manually controlled with a flow control valve (FCV-*-1-1). This valve, in conjunction with the sample gas flow monitor is provided as an aid to tank farm personnel to ensure correct flow through the main sampling loop. There are two major causes for decreased sample flow: 1. Sample flow elimination due to sample pump failure. 2. Sample flow reduction due to plugged particulate filters. The decrease in flow due to plugged filters would most likely be a slow process, unless an event produced a large amount of airborne contaminants.

3.1.5.1 Electro Chemical % H₂ Monitor Sensor Cell

The hydrogen sensing cells (NE-*-6/12-1) are electrochemical type cells that generate an electrical signal as a function of the H₂ gas partial pressure. The cell electrochemically reduces the oxygen and oxidizes the hydrogen on a catalytically active electrode in intimate contact with a gas permeable membrane. Thus the membrane and not the active sensor components, is in contact with the sample gas. The sensor is sealed at manufacture with two electrodes internally joined by a highly ionized electrolyte solution, and externally joined through a temperature compensation network. Hydrogen partial pressure is indicated by the millivolt signal level developed across the resistive compensation network, resulting from the electron exchange between the electrodes. It is this measurement that is converted by the electronics to a visual and electrical indication of concentration in volume percent.

The cell linear range is from nominally 0 to 50% hydrogen, but the signal conditioning transmitter can be configured over a variety of ranges. The NIT-*-6-1 is ranged from 0-10% and NIT-*-12-1 is ranged from 0-1%. The cell response time is shortest for lower hydrogen concentrations, but for high concentrations the output is capable of reaching 90% of the final value in two minutes or less after applying a step increase or decrease of at least 2% hydrogen concentration. The cell accuracy is equal to or greater than the absolute value of $\pm 0.2\%$ H₂ between 0 and 10%. The repeatability is equal to or better than $\pm 1.0\%$ of full scale when tested over a minimum of an eight hour period with the hydrogen level increasing. The temperature stability is equal to or better than $\pm 0.009\%$ H₂/C°.

The cell will operate with a sample flow rate of 0.047 to 0.708 L/Sec. (0.1 to 1.5 CFM), a calibration flow rate of 7.866 to 23.60 cc/Sec. (1 to 3 CFH), a sample pressure of -17.24 to 417.1 kPa (12 to 75 PSIA), and a sample temperature of 21 to 49°C (70 to 120°F). Since the cell measures partial pressures of hydrogen in the sampled gas, its accuracy is affected by both temperature and pressure. Therefore, since it is important to maintain constant cell temperature and pressure as a function of sample flow, the system is designed to operate with a sample flow of 0.472 SL/Sec. (1.0 SCFM), a calibration flow rate of 15.73 cc/Sec. (2 CFH), a sample pressure of -17.24 to -10.34 kPa (12 to 13 PSIA), and a temperature of 21°C (70°F). The cell has a minimum operating life of one year.

The cell is calibrated with standard gasses. By introducing the calibration gas at a pressure slightly higher than the process pressure, sample gas in the measuring plenum is displaced by the calibration standard and the cell output is generated only from the calibration gas.

This hydrogen sensor was chosen because of its inherently safe capability to monitor the potentially flammable hydrogen gas samples from the tank vapor space. There is no measurable heat generated during the electrochemical reaction and no stored energy in the chemical cell. The maximum voltage developed in the cell is 0.1 VDC and the maximum current that can be delivered is below 0.1 ADC.

3.1.5.2 Sample Line Vacuum Pressure Indicator

The sample line vacuum pressure indicator (PI-*-8-1) provides a visual display of the sample line pressure for operators and tank farm personnel. The range is 101.4 kPa (30"Hg), with an accuracy of $\pm 5\%$ of full scale, and an ambient temperature range of -40 to 66°C (-40 to 150°F). The system pressure at the detection point is nominally -10.34 kPa (13 PSIA).

3.1.5.3 In-Line Laminar Flow Measuring Element

The in-line flow measuring element (FE-*-7-1) was selected primarily because it is an intrinsically safe apparatus and for its linear response to flow at constant operating conditions of temperature, pressure and gas composition. The flow element is an all stainless steel unit. It is designed for a maximum pressure of 689.5 kPa (100 PSIG) and a maximum temperature of 66°C (150°F). The flow element is calibrated by the vendor and is supplied with a unique calibration factor and flow curve in terms of cubic feet per minute versus differential pressure in inches of water at 101.4 kPa (29.92 inches Hg) absolute pressure and 21°C (70°F).

The sampling system imposes some inherent difficulties in flow measurements due to temperature, sample gas composition, and system vacuum pressures. Refer to WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Sample Gas Flow Measurement Analysis" for the flow element range selection, temperature adjustment factors, gas composition adjustment factors, and pressure effects on indicated flow.

3.1.5.4 Sample Flow Control Valve

The flow control valve (FCV-*-1-1) allows the system operators to manually adjust the main loop flow when necessary. The preferred cell sample flow rate is 0.472 SL/Sec. (1.0 SCFM).

3.1.6 Gas Grab Sampling Loop

A grab sample station in the enclosure permits system operators to collect gas specimens while monitoring the gas sample stream. The grab samples are taken automatically for five minutes when the sample gas hydrogen concentration exceeds the high hydrogen alarm preset level, normally 0.75% H₂. The grab sample flow is controlled and monitored by a rotameter and flow control valve upstream of the grab sample cylinders. A Grab Sample push button on the front of the internal instrument panel permits operator initiation of the grab sample. Subsequent grab samples are inhibited until the Reset Sampler push button on the internal instrument panel is depressed to enable the system control logic.

Gas grab sampling is relatively easy. The gas cylinders are inserted in the assembly using ring seal vacuum tube fittings. The loop manual isolation valve MV-*-3-3 remains open during normal system operation. The rotameter and associated flow control valve (FI-*-3-1) is preset for nominally 10% of the main loop flow. The manual collection cylinder valves are opened to prepare for the next sample. Two normally closed electrically operated solenoid valves (EV-*-3-1/2) are energized automatically or manually to permit grab sample flow for a preset time of five minutes. Following a grab sample collection the following events take place:

- * The individual cylinder valves are closed
- * The sample cylinders are removed from the enclosure
- * New sample cylinders are installed in preparation for the next sample
- * The Reset Sampler push button is depressed to enable the system. The two Reset Sampler lights, one on the interior instrument panel and one on the enclosure door are extinguished.

3.1.6.1 Grab Sample Assembly

The gas bottles used to collect the gas specimens are made of low carbon stainless steel material, have an internal volume of 70 cc and each weigh approximately 310 grams (10 ounces). The pressure rating is 12,411 kPa (1800 PSI).

3.1.6.2 Grab Sampling Loop Flow Indicator

The flow indicator (FI-*-3-1) with integral flow control valve used for the grab sampling loop is a low flow industrial rotameter with a range of 31.5 to 315 cc/Sec. (4 to 40 CFH). Accuracy is $\pm 2\%$ of full scale. Sight tube material is borosilicate glass. The float is made of 316 stainless steel and seat material is Viton.

3.1.6.3 Grab Sampling Electrical Solenoid Valves

The normally closed sub-miniature electrical solenoid control valves (EV-*-3-1/2) are constructed with a stainless steel body in contact with the gas stream. The valve seals are Viton. The nominal operating range is between 0 and 57°C (32 and 135°F).

3.1.7 Sampling Vacuum Pump

A diaphragm vacuum pump (P-*-1-1) is used to draw the sample gas through the system and is located outside the enclosure on a support frame above the ground on the shaded, leeward side of the enclosure below the air conditioner unit. A protective cover is placed over the pump. The pump is a metal bellows type with a capacity of 0-1.42 L/Sec. (0-3 CFM) of air flow. The sample pump is designed for closed loop gas operation and is qualified to be totally submerged in a Class 1 Division 1 Group D environment or a Class 2, Division 1, Group E,F,G environment. Internal valve seals are made of Viton material and no wearing surfaces are exposed to the gas sample stream. The pump housing and bellow assembly provide a barrier between the sample gas and the pump motor electrics. The pump is able to draw a sample under pressures between -2.99 and 14.9 kPa (-12 and +60 inches of water) and be exposed to condensed vapors considered to have a pH from 8 to 12. The pump operating temperatures will remain acceptable by the north shade in the summer and the pump/motor self heating in the winter.

3.1.8 Sample Exhaust Back-flow Preventer

Located just downstream of the vacuum pump discharge in the sample return line, is a sample exhaust back-flow preventer (BFP-*-1-2) used to isolate the pump and sample system from any parallel monitoring systems. The back-flow preventer (BFP) is made of 316 stainless steel. Seat material is Teflon and the operating temperature of the valves is -73 to 232°C (-100 to 450°F). Cracking pressure is specified at 0.69 kPa (0.1 PSI). The BFPs are considered inherently safe apparatus.

3.2 Gas Sampling Instrumentation System

The Gas Sampling Instrumentation System is comprised of electronics necessary for the acquisition, display and transmission of data from the detection of the sample gas hydrogen. Also included are alarms necessary for the timely response by tank farm personnel to a gas release event or enclosure trouble. Many of these instruments are indicating transmitters for the data transmission from the sensors in the Gas Sampling Pneumatic System to recorders, alarms, and terminal blocks for remote data access. Included in this system are electrical intrinsic safety barriers between the sample stream sensors and the electronic signal conditioning.

3.2.1 Electro Chemical H₂ Monitor System

The hydrogen sensors (NE-*-6-1 and NE-*-12-1) generate an electrical signal proportional to the percent concentration of hydrogen by volume. The electrical signal generated by the hydrogen sensor/cell is processed by the respective indicating transmitters (NIT-*-6-1 and NIT-*-12-1). Here the percent hydrogen concentration present in the sample stream is digitally displayed, and the electrical signal generated by the hydrogen sensor/cell is converted to a 4-20 mADC signal.

Intrinsic safety barriers (EB-*-6-1 and EB-*-12-1) are installed between the electrochemical cell and the indicating transmitter to limit any voltage or current reaching the hydrogen cell due to a failure in the transmitter circuit. This barrier provides an added measure of security against a possible gas ignition.

The current output of the transmitters NIT-*-6-1 and NIT-*-12-1 is interfaced both to a terminal block for remote data acquisition access, and to a strip chart recorder (NR-*-6/12/SP-1) Channel 1 and 2 respectively, for local recording of the percent concentration of hydrogen.

3.2.1.1 Intrinsic Safety Barrier

The intrinsic safety barriers (EB-*-6/12-1) used are current and voltage limiting assemblies which are designed and constructed to requirements described by ANSI/UL 913 (formerly NFPA 493). They are used for positive potential dc with respect to ground. As zener diodes alone are not considered to be "protective components" they are applied redundantly with the addition of a fuse and resistor to protect against excessive voltage and current. When operating conditions are normal, the Intrinsic Safety Barriers conduct electrical signals in the circuit with negligible attenuation. In the event of excessive voltage being applied to the barrier's nonintrinsically safe terminals, the zener diodes will conduct, shunting the resultant excessive current to ground through a fuse in the nonhazardous location. Until the zener shunt current is sufficient to open the fuse, the zener diodes become a voltage source for the intrinsically safe circuit. A series resistor, on the barrier intrinsically safe side, limits the circuit current, thereby limiting energy levels below those required to ignite the hazardous atmosphere.

The terminals which provide connection for the intrinsically safe field wiring are identified by a blue terminal cover and are to be kept ≥ 5.08 cm (≥ 2 inches) distance from the terminal connections for nonintrinsically safe wiring.

Technical specifications include the following:

- *Operating temperature range of -40 to 50°C (-40 to 122°F)
- *Relative humidity range of 5% to 95%
- *Temperature effect on response characteristics of $< 0.25\%$ per K
- *Mean time between failure of 700 years

3.2.1.2 % H₂ Indicating Transmitters

The %H₂ indicating transmitters (NIT-*-6/12-1) are microprocessor based transmitters that accept the mV output signal produced by the electrochemical hydrogen sensor/cells and provide proportional analog 4-20 mADC output signal. The units are programmable via front push buttons to provide a linear response to the hydrogen cell output signal range. The indicating transmitters are programmed to digitally display the percent concentration of hydrogen locally.

Technical specifications include the following:

- *The transmitter is capable of driving 500 ohms of purely resistive load.
- *Step response of 1.8 seconds to 99.9%
- *Maximum error of ±0.005% of reading
- *Operating temperature of 0 to 50°C (32 to 122°F)

3.2.2 Sample Flow Measurement and Alarm System

The sample gas flow monitor consists of a laminar flow element (FE-*-7-1) and a differential pressure transmitter (FIT-*-7-1) located in the main hydrogen sample gas line. As the sample gas flows through the flow element, the resultant pressure drop is measured by the pressure transmitter which generates a 4-20 milliamp signal proportional to the gas flow rate. This signal is interfaced to a dc input limit alarm (FASL-*-7-1). If the flow rate drops below a preset value, the dc input limit alarm de-energizes a relay to open a normally open contact. This contact serves an input to the programmable logic controller (YVC-*-01) to annunciate the low hydrogen flow alarm.

3.2.2.1 Sample Flow Indicating Transmitter

The sample flow indicating transmitter used for flow measurement is a high performance smart transmitter which utilizes microprocessor technology in its design. The transmitter is composed of two modules, the sensor module and the electronics module. The sensor module incorporates a highly accurate capacitance sensor. The capacitance cell is laser-welded, and isolated mechanically, electrically and thermally from the process medium and the external environment.

The sensor module includes a temperature sensing circuit to compensate for thermal effects. Unique temperature coefficients for each transmitter are stored in the sensor module memory to ensure precise signal correction during operation over a wide temperature range. The analog to digital conversion is performed in the sensor module. The local readout provides zero to full scale display in engineering units and percent of range. The output section of the module accurately converts the digital signal to the selected 4-20mA analog process signal.

The differential pressure transmitter was selected for three main reasons, the ability to meet intrinsic safety and hazardous environment requirements, performance, and maintainability. The transmitter is designed to meet U.S. and international intrinsic safety and explosion-proof requirements. Maintenance is reduced due to the modular and digital design. Precise configuration and calibration of the pressure transmitter is interfaced through a hand held interface module. The input pressure range, engineering units, and offset are programmed into the nonvolatile EEPROM memory. Internal diagnostics are continually performed to assure proper performance. In the event of a problem, the transmitter output is driven to a user-selected analog warning signal level.

Technical specifications include the following:

- * Selected pressure range of 0 to 2.49 kPa (0 to 10 inches of water)
- * Transmitter reference accuracy $\pm 0.1\%$ of span
- * Stability $\pm 0.2\%$ of span for 12 months

- * Temperature effects $\pm 10^{\circ}\text{C}(\pm 50^{\circ}\text{F}) \pm 0.35\%$ of span
- * Total algebraic measurement error = $\pm 0.65\%$ of span

3.2.2.2 Sample Low Flow Alarm

A DC input limit alarm is used to annunciate the occurrence of low flow in the sample stream. The limit alarm is configured to operate in the fail-safe condition. In fail-safe operation, the relay is energized when the process is above the LO set point. The limit alarm has an adjustable dead-band setting. The alarm relay will trip at the set point, but will not return to its untripped condition until it rises above the LO dead-band. The input must remain below the set point for 100 milliseconds, uninterrupted, to qualify as a valid trip condition. Likewise, the input must rise above the dead-band and remain there for 100 milliseconds to return the alarm to an untripped condition. Set points are adjustable over 100% of the input span. In the fail-safe mode, a power failure results in a tripped condition.

The limit alarm is equipped with dual function top-mounted LED(s) for trip and line power status indication. The LED is normally green and indicates red in a tripped condition. Line power status is indicated by the illuminated LED.

Technical specifications include:

- * Repeatability (constant temperature) is better than 0.2% of full scale.
- * Temperature Stability of $\pm 0.05\%$ of span/ $^{\circ}\text{C}$
- * Operating Range of 0 to 60°C (32 to 140°F)
- * Relay Electrical Life: 10^5 operations at rated load.

3.2.3 H₂ Monitor Recording and Alarm System

The first two recording channels of a three channel strip chart recorder (NR-*6/12/SP-1) accept the 4-20 mA signals from the two electrochemical % H₂ monitors. The 4-20 mA signal output of transmitters NIT-*6-1 and NIT-*12-1 are interfaced to channels 1 and 2, respectively, of the strip chart recorder for local recording of the percent hydrogen concentration.

Each recording channel is programmed to activate alarm relays at a preset hydrogen concentration. The activation of one relay opens a normally closed contact which serves as the input to a programmable logic controller. The programmable logic controller controls the local and remote annunciation of a high hydrogen alarm as well as initiating an automatic grab sample. The activation of another relay increases the strip chart drive speed to provide more resolution of the gas release event.

3.2.3.1 Strip Chart Recorder

The strip chart recorder used is a three channel continuous writing, variable speed programmable recorder. The recorder lists time, date, span, zero, chart speed and pen color identification on a routine basis based on chart speed. The pens are disposable felt-tip pens in red, green, blue, and purple. The paper is Z fold chart paper with a calibrated width of 100 mm.

Digital data printout includes channel number, tag number, scale marking (at 0 and 100% of chart with engineering units), chart speed, date and time. Program List Printout includes date and time, measuring range, tag number, engineering unit, alarms, and chart speed. Alarm printout includes channel number, H or L sign, and the time of alarm ON/OFF.

The recorder digital data display gives measured data, channel number, date and time, or chart speed.

Accuracy is based on range selected, but typically the digital display accuracy is $\pm 0.2\%$ of reading. The analog recording accuracy is $\pm(0.2\%$ of reading + 0.3% of span), with $\pm 0.5\%$ of span as worst case. Dead-band is less than 0.2% of span.

The ambient operating temperature is 5° to 40°C (41° to 104°F), with relative humidity of 45 to 85%. Ambient temperature effect on the display is $\pm 0.1\%$ of reading + 1 digit and the effect on recording is $\pm 0.3\%$ of span for 10°C variation in ambient temperature.

Three 1.5V batteries maintain all programming when power is removed.

3.2.4 Sample Gas Line Temperature Monitoring and Alarm System

The temperature element (TE-*-14-1) monitors the temperature of the sample gas line and provides a representative electrical signal to an indicating temperature controller (TIC-*-14-1). The thermocouple is routed from the enclosure to the point of measurement on the heat traced insulated sample gas lines (sample line and sample return). The sheath is secured along the length of the insulation jacket. At the point of measurement, the insulation is cut away for attachment of the thermocouple end to the inlet process tube where it is centered under a stainless steel band that holds it in place.

The heat trace is needed to assure a nominal sample gas temperature of 21 to 49°C (70 to 120°F) to the electrochemical hydrogen sensor and to prevent condensation in the gas line. Thermal analysis calculations indicate that the process tube temperature should be at least 27°C (80°F) to assure a gas temperature of at least 21°C (70°F). Reference WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Thermal Analysis for System Heat Trace".

Should the heat trace or the heat trace control fail, and the tube temperature fall below the alarm set point, the temperature controller will provide an open contact to the programmable logic controller for the local annunciation of a low gas temperature alarm and remote trouble alarm.

3.2.4.1 Thermocouple

The temperature sensing element is a 1/16" diameter, stainless steel sheathed, mineral insulated, ungrounded type K thermocouple. Some features of the thermocouple construction include moistureproof, thermal shock resistant, fast responding, accurate, formable, durable, and compact. The sheath length is 6', and lead-wire length is 6 feet. It has a coiled spring strain relief that protects wire against sharp bends in the transition area.

The thermocouple penetrates the enclosure through a weatherproof compression fitting.

3.2.4.2 Temperature Indicating Controller

The temperature indicating controller used is a microprocessor based temperature controller with a user interface. The controller output 1 provides a nonisolated 5 Vdc pulse for driving external solid state relays. The controller output 2 is a single pole double throw relay contact for alarming. The controller is configured as an ON/OFF control with a minimal dead-band and a type K thermocouple input. The display is a 3½ digit green LED, with a user configurable 1 or 0.1° resolution, error indication, and deviation from set point indicators (3 LEDs). For type K thermocouple, the linearized range is 0-1200°C with a linearity tolerance of 1°C and a preset span of 400°C. Units are °C/°F switchable.

Technical specifications include:

- * Accuracy: $\pm 0.25\%$ full scale $\pm 1^\circ\text{C}$ ($\pm 0.5^\circ\text{C}$ in 0.1°C resolution mode)
- * Control Stability: $\pm 0.15\%$ full scale
- * Sample Rate: 3 per second
- * Auto Calibration: Every 5 seconds with rezero of cold junction compensation
- * Ambient operating temperature range: 4 to 49°C (40 to 120°F)
- * Non-volatile memory

3.2.5 Calibration Gas Line Temperature Monitoring and Alarm System

The temperature element (TE-*-15-1) monitors the temperature of the calibration gas line and provides a representative electrical signal to an indicating temperature controller (TIC-*-15-1). The thermocouple is routed from the enclosure to the point of measurement on the heat traced insulated calibration gas supply line. The sheath is secured along the length of the insulation jacket. At the point of measurement, the insulation is cut away for attachment of the thermocouple end to the process tubing where it is centered under a stainless steel band that holds it in place.

The heat trace is needed to assure a nominal calibration gas temperature of 21 to 49°C (70 to 120°F) to the electrochemical hydrogen sensor. The thermocouple will measure the process tube temperature. Thermal analysis calculations indicate that the process tube temperature should be at least 28°C (82°F) to assure a gas temperature of at least 21°C (70°F). Reference WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Thermal Analysis for System Heat Trace".

Should the heat trace or heat trace control fail and the tube temperature falls below alarm set point, the temperature controller will provide an open contact to the programmable logic controller for the local annunciation of a low gas temperature alarm and a remote trouble alarm.

3.2.5.1 Thermocouple

The thermocouple and compression fittings used are identical to the ones used in the sample gas line temperature monitoring and alarm system.

3.2.5.2 Temperature Indicating Controller

The temperature indicating controller used is identical to the one used for the sample gas line temperature monitoring and alarm system.

3.2.6 Environmental Enclosure Temperature Monitoring and Alarm System

The temperature element (TE-*-16-1) monitors the enclosure temperature and provides a representative electrical signal to an indicating controller (TI-*-16-1). Optimally, the enclosure temperature should be kept between 21-27°C (70-80°F) to keep the calibration gases and sample gases above 21°C (70°F) (gas temperature necessary for electrochemical hydrogen monitoring response time), since heat trace will be terminated as gas lines enter the enclosure. In addition, enclosed instruments must be kept within their operating temperature ranges.

A heater and air conditioner are included in the enclosure to ensure an internal temperature of 21-27°C (70-80°F) year round. Should these components fail, and the enclosure temperature become either too hot or too cold, the indicating controller will open a contact which serves as an input to the programmable logic controller for the local annunciation of a high/low cabinet (enclosure) temperature alarm and a local and remote trouble alarm.

3.2.6.1 Thermocouple

The thermocouple used for monitoring of the enclosure temperature is nearly identical to the one used in the sample gas line temperature monitoring and alarm system. The only difference is a sheath and lead-wire length.

3.2.6.2 Temperature Indicating Controller

The temperature indicating controller used is nearly identical to the one used for the sample gas line temperature monitoring and alarm system. The only difference is that outputs 1 and 2 are both single pole double throw relay contacts for alarming.

3.3 Calibration Gas System

Cylinders containing standard gasses are installed to support calibration and maintenance tasks of the electrochemical monitors. The cylinders are placed in a gas bottle rack on the enclosure pad. A zero gas mixture of nominally 100ppm hydrogen and balance air is used to adjust the low end of the %H₂ sensors. The span gas mixture of nominally 5.0% hydrogen mixed with balance nitrogen is used for the top end adjustment of the %H₂ sensors. A mid-range standard gas of nominally 1,000ppm hydrogen in balance air, is provided for an on-line calibration check during system operation.

The calibration functions are implemented through manually operated local valves (MV-*-5-1, MV-*-5-2, MV-*-5-3, MV-*-5-4, MV-*-5-5 and MV-*-5-6). The flow indicator with integral flow control valve (FI-*-5-1) is included to ensure the proper flow rate to the hydrogen sensors. Pressure gauges and low pressure regulators (PCV/PI-*-5-1, PCV/PI-*-5-2, PCV/PI-*-5-3) are included to assure the proper supply pressure. A 15 micron filter (F-*-5-1) filters the outside air when purging the calibration gas manifold.

3.3.1 Calibration Gas Supply

The vendor certified standard calibration gasses are provided in size 1A compressed gas bottles with nominal 100ppm H₂ in air, 5.0% H₂ in nitrogen and 1,000ppm H₂ in air. The 100 and 1,000ppm gasses are prepared and analyzed to a tolerance of ±1% of component. The 5% gas is prepared and analyzed to a tolerance of ±0.02% absolute. All gasses are traceable to NIST to ±0.02% absolute or ±1% of the component, whichever is smaller.

3.3.2 Calibration Gas Flow Control

The flow indicator (FI-*-5-1) has an inlet control valve and is specifically designed for general purpose measurement and control of low volume purge flows. The tube has a 7.62 cm (3 inch) scale with a maximum capacity of 19.66 cc/Sec. (2.5 CFH) air.

The frame is made of 302 stainless steel. The end fittings are made of 316 stainless steel. The O-rings are made of Viton with ethylene propylene rubber and the float material is 316 stainless steel. Tube retainer material is 316 stainless steel and a control valve is included at the inlet.

Technical Specifications include:

- * Accuracy of ± 10% of full scale.
- * Operating range of 10:1
- * Pressure limit of 1,724 kPa (250 PSIG)
- * Temperature limit of 121°C (250°F)

3.3.3 Calibration Pressure Regulators/Pressure Indicators

The two stage pressure regulators/indicators (PCV/PI) used are designed for hydrogen in balance air or nitrogen. These regulators are designed with metal diaphragms and provide sensitive pressure control. Design features include: helium leak certification to 2.0×10^{-8} cc/sec, porous metal filter at inlet to the regulator, interstage relief valve to protect the second stage from over pressurization, and an outlet isolation diaphragm valve. Construction materials for the body and bonnets are chrome-plated forged brass. Diaphragm material is 302 Stainless Steel, seat material is Kel-F, and seal material is Viton.

Technical specifications include:

- * Maximum Inlet Pressure: 20,700 kPa (3000 PSIG)
- * Maximum Flow Rate (at 13,790 kPa, N₂): 1,180 cc/Sec. (150 CFH)
- * Flow Coefficient (C_v): 0.02
- * Operating Temperature: -18 to 66°C (0 to 150°F)
- * Delivery Pressure Range: 0-103 kPa (0-15 PSIG)
- * Delivery Pressure Gauge: 0-207 kPa (0-30 PSIG)
- * Cylinder Pressure Gauge: 0-20,700 kPa (0-3000 PSIG)

3.3.4 Calibration Gas Filter

The calibration gas filter (F-*-5-1) is an all welded in-line filter for leak proof service. It features a 5.72 cm² (2.25 in.²) filtration area, a pleated mesh element. Structural support for the element is provided by retainer screens which are welded on the perimeter of the filter, together with the element during fabrication. The body part, retainer screens, and pleated elements are made of 316 stainless steel.

The 15 micron filter is rated for a differential pressure drop to atmosphere of 68.9 kPa (10 PSI), at a flow capacity of 2.61 SL/Sec. (5.54 SCFM).

3.4 Alarm Annunciator and Control System

The alarm annunciator and control system is based upon ten system inputs to a programmable logic controller (PLC). Each input triggers multiple outputs. The programmable logic controller (YYC-*-01) is responsible for processing the inputs and triggering the appropriate outputs for local or remote annunciation and control. Refer to Table 1.0 for the system inputs, alarm annunciators and controls generated from those alarms. Refer to drawing H-2-817852, *Standard-B Hydrogen Monitoring System One-Line & Elementary Diagrams*, for the following discussion.

TABLE 1.0

System Inputs	Input to PLC	Alarm Generated	Annunciators/Outputs
Electro Chemical High Range % H ₂ Monitor System	Strip Chart Recorder NC Contact (NASH-*-6-1) OPEN above set point	High Hydrogen	Red Strobe Light Beacon (YAL-*-10-2) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-10-1) Grab Sample Valves (EV-*-3-1/2) Grab Sample Lamp (HSL-*-22-1) Reset Sampler Lamp (HSL-*-23-1) Remote High Hydrogen Alarm
Electro Chemical Low Range % H ₂ Monitor System	Strip Chart Recorder NC Contact (NASH-*-12-1) OPEN above set point	High Hydrogen	Red Strobe Light Beacon (YAL-*-10-2) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-10-1) Grab Sample Valves (EV-*-3-1/2) Grab Sample Lamp (HSL-*-22-1) Reset Sampler Lamp (HSL-*-23-1) Remote High Hydrogen Alarm
Sample Flow Measurement System	DC input Limit Alarm NO Contact (FASL-*-7-1) OPEN below set point	Low Hydrogen Flow	Amber Strobe Light Beacon (YAL-*-18-1) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-7-1) Remote Trouble Alarm
Sample Gas Line Temperature Monitoring System	Temperature Controller NO Contact (TASL-*-14-1) OPEN below set point	Gas Temp Low	Amber Strobe Light Beacon (YAL-*-18-1) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-14/15-1) Remote Trouble Alarm
Calibration Gas Line Temperature Monitoring System	Temperature Controller NO Contact (TASL-*-15-1) OPEN below set point	Gas Temp Low	Amber Strobe Light Beacon (YAL-*-18-1) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-14/15-1) Remote Trouble Alarm
Enclosure Temperature Monitoring System	Temperature Controller NO Contact (TASHL-*-16-1) OPEN above and below set points	Cabinet Temp (Enclosure)	Amber Strobe Light Beacon (YAL-*-18-1) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamp (YAL-*-16-1) Remote Trouble Alarm

TABLE 1.0

System Inputs	Input to PLC	Alarm Generated	Annunciators/Outputs
Grab Sample System	Grab Sample push button NC Contact (HS-*-22-1) in series with NC High H ₂ Contact (NASH-*-12-1)	High Hydrogen (Momentary)	Red Strobe Light Beacon (YAL-*-10-2) Audible Wavering Horn (YAH-*-9-1) Remote High Hydrogen Alarm (Previous Alarms are Momentary) Enclosure Door Lamp (YAL-*-10-1) Grab Sample Valves (EV-*-3-1/2) Grab Sample Lamp (HSL-*-22-1) Reset Sampler Lamp (HSL-*-23-1)
Grab Sample System	Reset Sampler push button NC Contact (HS-*-23-1)	Not Applicable	Enables the following controls and annunciators: Grab Sample Valves (EV-*-3-1/2) Grab Sample Lamp (HSL-*-22-1) Reset Sampler Lamp (HSL-*-23-1)
Alarm Test System	Alarm Test push button NC Contact (HS-*-21-1)	All Annunciators Except Grab Sample and Reset Sampler	Red Strobe Light Beacon (YAL-*-10-2) Amber Strobe Light Beacon (YAL-*-18-1) Audible Wavering Horn (YAH-*-9-1) Enclosure Door Lamps (YAL-*-7,10,14/15,16-1) Remote High Hydrogen Alarm Remote Cabinet (Enclosure) Trouble Alarm
Alarm Test System	Alarm Reset push button NC Contact (HS-*-20-1)	Not Applicable	Resets All Annunciators Except Reset Sampler if the alarm condition has previously cleared. (Does not affect Reset Sampler and Grab Sampler)
Horn Acknowledge	Horn Acknowledge push button NC Contact (HS-*-19-1)	Not Applicable	Resets/Silences the horn but does not lock it out for subsequent alarms.

The inputs to the PLC are designed to activate the annunciators on loss of power (fail safe condition), with the exception of the strip chart recorder high hydrogen contacts. Loss of power to the hydrogen indicating transmitters and the strip chart recorder will not produce a "false positive", i.e. a high hydrogen alarm will not be generated. Loss of power to the PLC will activate the remote annunciators and the local beacons. On loss of incoming power to the entire system, the remote alarm contacts (which are also designed for fail-safe operation) will open, generating a remote alarm.

The high hydrogen (red) beacon, the trouble (amber) beacon, the remote alarms, and the audible wavering horn automatically reset on loss of the alarm condition. Conversely, the enclosure door alarm indicator lamps retain their alarm state after the loss of the alarm condition, until manually reset.

The enclosure door alarm indicator lamps are turned on directly by a PLC output. Conversely, on a high hydrogen alarm condition that is triggered from either electrochemical %H₂ monitor system input, the PLC de-energizes a high hydrogen relay (BY-*-10-1) to provide an open contact to a remote annunciator interface (a terminal block) and turn on the high hydrogen beacon. Likewise, on any of the other alarm conditions, the PLC de-energizes a trouble relay (BY-*-18-1) to turn on the trouble beacon and provide an open contact to a remote annunciator interface (a terminal block).

The enclosure alarm annunciator horn (YAH-*-9-1) is activated with each alarm. The HORN ACKNOWLEDGE push button (HS-*-19-1) allows the operator to disable the horn during an alarm condition without disabling the ability for another system input to activate the horn.

The ALARM RESET push button (HS-*-20-1) clears all local alarm annunciator lamps, if the alarm condition has returned to normal.

For example, if a low sample gas temperature condition is met. The horn sounds, the trouble (amber) beacon is activated, the low gas temperature enclosure door alarm lamp is turned on and a remote trouble annunciator signal is provided. An operator would be sent to investigate the problem. The operator would acknowledge the horn and proceed with troubleshooting. If an instant later, a low flow condition is met. The horn turns on again, and now the low hydrogen flow enclosure door alarm lamp is turned on. After acknowledging the horn and correcting both problems, the trouble beacon and the remote trouble annunciator automatically reset. The operator then pushes the ALARM RESET button, to reset low gas temperature and low hydrogen flow enclosure door alarm lamps.

The beacons, horn, enclosure door alarm lamps and remote annunciation can all be tested at the same time with the ALARM TEST (HS-*-21-1) push button provided on the enclosure door. Consequently, the programmable logic controller outputs are also verified with this test.

3.4.1 Programmable Logic Controller

Programmable Logic Controllers offer many advantages over other control devices. These advantages typically are:

- Improved reliability
- Easier maintainability
- Smaller space required
- Programmable as system requirements change
- Less expensive than equivalent hard-wired systems
- More flexible (can perform more functions)
- Reusable

The programmable controller used for the alarm annunciation system requires only 247.5 cm² (97.5 in²) of mounting area including wiring access and provides 24 I/Os, which includes 15 inputs and 9 outputs. Conversely, approximately 20+ electro-mechanical relays would have been required to implement the relay logic necessary to fulfill the Hydrogen Monitoring System Requirements. The nominal dimensions of a single electro-mechanical relay including wiring access are 7.6 cm(H) x 12.7 cm(W) x 7.6 cm(D). Physically locating 20 relays would require approximately 762cm² and an extensive amount of wiring.

The Basic Unit, requires 115 VAC input, and allows connection to 115/230 VAC output circuitry. The internal logic needed to program the PLC and the hard wiring setup is documented on engineering drawings H-2-817852, *Standard-B Hydrogen Monitoring System One Line, Elementary Diagrams*, and H-2-818213, *Standard-B Hydrogen Monitoring System P.L.C. Ladder Diagram*.

The PLC system design is presented in WHC-SD-WM-CSDD-004, *The Family of Standard Hydrogen Monitoring System's Computer Software Design Description* (Bender 1994).

3.4.2 Alarm Beacons and Horn

The beacons used for the high hydrogen beacon (YAL-*-10-2) and the trouble beacon (YAL-*-18-1) are heavy duty strobe light beacons. Features include a shatter-resistant weatherproof Lexan optic lens, and no moving parts. The flash rate is 1.1 FPS.

The horn (YAH-*-9-1) used is a solid state signal horn. It has an intermittent loud tone and is panel mountable. The sound output at 0.6 m (2 feet) is 80 to 95 dB. The temperature range is -30 to 65°C (-22 to 149°F).

3.4.3 Enclosure Lamps and Controls

Neon AC/DC pilot lights supplied with an amber color cap are used for all the enclosure door lamps (YAL-*-7-1, YAL-*-10-1, YAL-*-14/15-1, YAL-*-16-1, and YAL-*-23-1).

A momentary contact push button is used for the horn acknowledge push button (HS-*-19-1), the alarm reset push button (HS-*-20-1), and the alarm test push button (HS-*-21-1). The push button is a NEMA type 4/13 Watertight/Oiltight black flush head push button. The normally closed contact features a "quick make, quick break" snap action mechanism.

The high hydrogen alarm relay (BY-*-10-1) and the trouble alarm relay (BY-*-18-1) are double pole double contact relays with ungrounded frames and contacts. The relays are enclosed in a clear polycarbonate dust cover and have silver cadmium oxide contacts rated 10 amps at 250 VAC.

3.5 Environmental Enclosure Power Distribution

AC Power distribution for the sample pump, heater, air conditioner, heat trace, enclosure instrumentation, and a maintenance equipment outlet is via a 240/120 VAC feed. The power source will vary with each tank farm location and will be listed on H-2-817852, *Standard-B Hydrogen Monitor System One Line, Elementary Diagrams*. The power needs for the SHMS are specifically: 240 VAC at 8.5 Amps and 120 VAC at 16.3 Amps. Refer to Drawing H-2-817852 for the following:

The sample pump requires 240 VAC at 3.5 Amps and overcurrent protection is provided via a two pole 15 Amp circuit breaker (CB-3&4).

The heater (HTR-*-01) and air conditioner (ACU-*-01) require 240 VAC at 3.5 and 5 Amps respectively. A two pole 15 Amp circuit breaker (CB-1&2) provides overcurrent protection for both. A two pole relay is used in the circuit in such a way that simultaneous operation of both is not possible. A relay coil (K1) is placed in parallel with the air conditioner condenser blower. When the air conditioner is operating, the relay coil (K1) will be energized, opening normally closed contacts (K1-1, and K1-2) in the heater power circuit, effectively cutting off power to the heater. Conversely, when the air conditioner is not operating, the relay coil (K1) is de-energized, closing contacts K1-1 and K1-2, effectively completing the heater power circuit.

Heat trace for the sample gas line (HT-*-14-1) and the calibration gas line (HT-*-15-1) requires 120 VAC at 8.3 Amps maximum. A single pole 15 Amp circuit breaker (CB-5) provides overcurrent protection for both heat trace power circuits. Temperature controllers energize solid state relays (JY-*-14-1 or JY-*-15-1) whenever the corresponding heat trace (HT-*-14-1 and HT-*-15-1) is needed. Energizing the relays will complete the heat trace power circuit by gating on zero fired triac circuits, providing power to the heat trace.

An enclosure light (LT1) and a ground fault interrupting receptacle are included in the enclosure for maintenance purposes. The expected load for the receptacle and lamp should not exceed 4 Amps. A single pole 15 Amp circuit breaker (CB-6) provides overcurrent protection for both. Light operation is via a hand switch on the enclosure door.

All of the instruments require 120 VAC at a maximum 4 Amps. A single pole 15 Amp circuit breaker (CB-7) feeds a 750 VA isolation transformer which provides power to the 120 VAC Instrument Line. The transformer is included to protect the instruments against power line noise due to electrical disturbances such as lightning, utility network switching and the operation of electric motors. Each instrument that is fed off of this 120 VAC line is individually fused. The 120 VAC Instrumentation Line also feeds a 24 VDC power supply. The Flow Indicating Transmitter (FIT-*-7-1) requires 24 VDC at 0.02 Amp.

3.5.1 AC Power Distribution Components

The 15 Amp circuit breakers used in the power distribution design are screw terminal type breakers. The operating temperature range is -20 to 60°C (-4 to 140°F). The electromechanical life is rated at 30,000 operations.

The relay coil (K1) used in the design of the heater/air conditioner power circuit is a double pole double throw contact.

The switch (SW1) used for interior light control is a hand switch with a single pole double throw contact.

The interior light used for the enclosure uses a 60 watt incandescent T-10 style bulb.

The isolation transformer used is a single phase, terminal style, with a power rating of 750 VA. The input and output voltages are both 120 VAC.

3.5.2 DC Power Distribution Components

The 24VDC power supply features include provision for remote sensing and external output adjustment. It is short circuit proof with electronic current limiting and automatic recovery.

Technical specifications include:

- * An ambient operating temperature of -20 to 71°C (-4 to 160°F).
- * Adjustment of ± 0.5 V
- * Output current of 2.0 Amps
- * Load regulation: 0.005%
- * Line regulation: 0.005%

3.6 Heat Trace and Environmental Control

Sample and calibration gas line temperature control is needed for two reasons. The first is to keep the sample gasses above the dew point, since they contain a relatively high concentration of water vapor. The second is to ensure the required response time from the electrochemical hydrogen monitor.

A temperature control set point of 29°C (85°F) has been established as the design temperature for all gas sample lines. The value of 29°C (85°F) was established to provide a 5.5°C (10°F) margin of error for the heat trace system above the worst case 24°C (75°F) dew point temperature (condensation temperature). The 24°C (75°F) temperature requirement was picked after reviewing wet/dry bulb temperatures taken for humidity measurements on the 101-SY exhaust header during the last two years. They showed a winter dew point of 14°C (57°F) and a summer dew point of 24°C (75°F). Preventing condensation is important to achieving measurement accuracy. Some gasses chemically react very quickly with water. If this reaction with water occurs in the sample lines then the gasses presented to the instruments is not the same as the gasses at the sample point. Heat trace is provided to prevent this measurement error.

The second reason for heat trace is to provide the electrochemical hydrogen sensor in the enclosure a gas sample between 24 and 49°C (75 and 120°F). The cell's response time to step changes in hydrogen increases as the sample temperature decreases below 21°C (70°F). Tests at 21°C (70°F) show a 120 second response for a 90% indication to a step change in hydrogen. This response time improves as the sample temperature increases until about 49°C (120°F) where effects of reduced sample stream humidity then start to increase response time. Measurements of exhaust temperature have been as low as 4°C (40°F) when the average daily January ambient temperature was around -18°C (0°F). The heat trace system is needed to raise the temperature of the winter gas samples to 27°C (80°F) before the gas sample enters the enclosure. The calibration gas lines are also heat traced to raise the gas temperatures from ambient to nominally 21°C (70°F) due to the outdoor location of the calibration gas bottles.

Enclosure temperature control is needed for two reasons. The first is to continue to keep the sample and calibration gasses that have been heat traced in the winter, at a minimum of 21°C (70°F). The second reason is to keep the enclosed instruments in their optimal operating temperature ranges which is nominally between 16 and 32°C (60 and 90°F).

3.6.1 Sample and Calibration Gas Line Temperature Control

Sample Gas Line Heat Trace Design

Refer to Figure 2 for a depiction of the sample gas line heat trace design.

The point of sample collection and sample return may be at a tank riser or on the tank ventilation exhaust header. The distance between the sample probe location and the sample return location will vary with each application. Nominally the distance will be 0.3-0.6 meter vertical or horizontal. The sample and return lines will come together to facilitate their support.

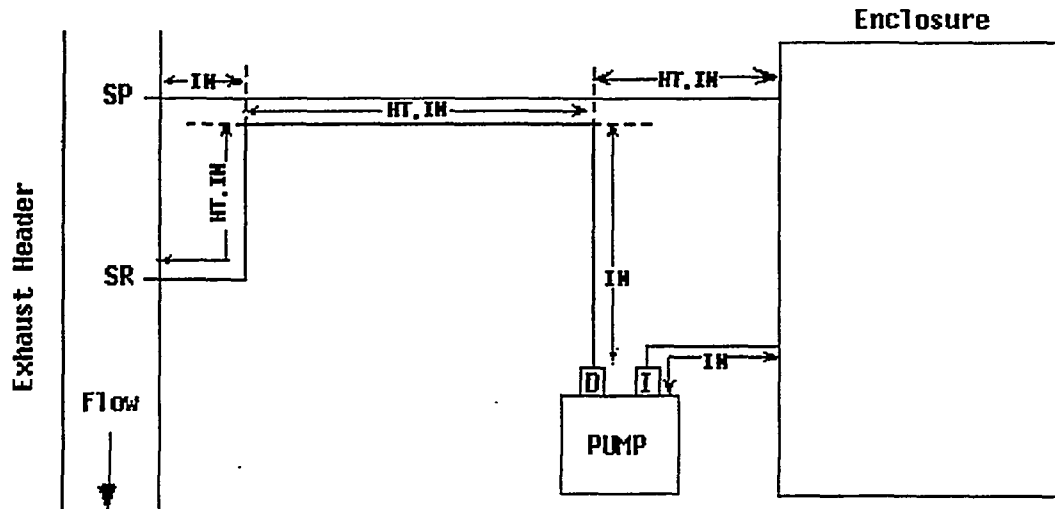
At the point they come together, a pre-heat traced pre-insulated tubing bundle with two ½" process tubes will be utilized up to the point where the gas lines split again, with the sample line advancing to the enclosure and the sample return line retreating from the pump discharge. Thermal analysis calculations verify that a 10 watts/foot heat trace is sufficient to heat the sample gas up to at least 21°C (70°F) for a minimum heat traced length of 5 meters. This analysis assumes worst case temperatures of -29°C (-20°F) for ambient and -1°C (30°F) for sample gas. Reference WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Thermal Analysis for System Heat Trace".

The electric heat trace will be extended from the point at which the sample return diverges from the tubing bundle to just short of the point where it is returned to the exhaust header. Insulating material will then be wrapped around the process tube and heat trace.

The distance from where the sample return line diverges from the tubing bundle to the pump discharge is approximately 1 foot and will be insulated only. The distance from where the sample return line exits the enclosure to the pump inlet is nominally 1 foot and will be insulated only. Reference WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Thermal Analysis for System Heat Trace" for verification that heat trace on these short runs is not necessary. The calculations do not take into account that the pump will be generating heat that will add to the heat content of the gas and thus are worst case calculations.

The other portion of the sample line that is not heat traced, but insulated only, is the run from the sample collection point to where the sample line and sample return meet.

FIGURE 2: HEAT TRACE DESIGN



Note: Drawing is not to scale

D = PUMP DISCHARGE
I = PUMP INLET
IH = INSULATED
HT = HEAT TRACED
SP = SAMPLE POINT
SR = SAMPLE RETURN

Calibration Gas Line Heat Trace Design

The calibration gas bottles will be located outdoors. Thus, the gas in these bottles will be at ambient temperature. Worst case gas temperatures of -29°C (-20°F) in the winter were assumed for the thermal analysis calculations.

The three calibration gas bottles will be tied into a single calibration gas line since only one calibration gas at a time will be used. The gas line proceeds to the enclosure and is approximately 3 meters in length. A preinsulated, pretraced tubing bundle with one $\frac{1}{4}$ " process tube will be used from the tee just short of the zero gas bottle to the point that the calibration gas line enters the enclosure. The thermal analysis calculations verify that a 10 watts/foot trace is sufficient to heat the calibration gas from a worst case of -29°C to 21°C (-20°F to 70°F) for a minimum heat traced length of 3 meters with the temperature set point of 28°C (82°F). Reference WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Thermal Analysis for System Heat Trace".

Heat Trace Control

Temperature elements (thermocouples) TE-*-14-1 and TE-*-15-1 monitor the temperature of the sample gas and calibration gas line respectively. They provide an electrical signal representing the temperature to indicating temperature controllers TIC-*-14-1 and TIC-*-15-1. The temperature controllers are able to control power to the heat trace HT-*-14-1 and HT-*-15-1 for each line via solid state relays JY-*-14-1 and JY-*-15-1.

3.6.1.1 Heat Trace System

The heat trace system uses a pre-traced, pre-insulated tubing bundle with two $\frac{1}{2}$ " process tubes for sample gas line heat tracing and a pretraced, preinsulated tubing bundle with one $\frac{1}{2}$ " process tube for calibration gas line heat tracing. The process lines and heat trace are arranged so they are always parallel inside the bundle. This configuration simplifies installation. The bundle is easy to bend during field routing and hookup since all the tubes bend together and not against each other.

The sample gas line heat trace bundle is composed of approximately 1.1 cm (0.45 inches) of fibrous glass insulation around $\frac{1}{2}$ " x 0.049" wall seamless 316 stainless steel tubing with an electric heat trace lying on top of both tubes. There is a weatherproof thermoplastic polyetherurethane elastomer jacket around the insulation that is hydrolytically stable, halogen free, abrasion resistance, and UV resistant. There is a minimum installation temperature of -40°C (-40°F) and a maximum process tube temperature of 121°C (250°F) continuous exposure power on.

The heat trace is a 10 watt/ft self-regulating type that can withstand 215°C (420°F) blow-down temperatures and has a tinned copper shield and fluoropolymer outer jacket. It is FM Approved for Class I, II, III Div. 2 Group B, C, D, F, and G.

Self-limiting (Self-regulating) heat tape was picked for its life expectancy. Self-limiting heat tape is not subject to burn out from localized over-heating caused by kinks or crossovers. Self-limiting heat tape has an electrically lossy material between two parallel copper conductors. The conductivity of the lossy material decreases as temperature rises, thereby decreasing the dissipated wattage per foot as the temperature of the heated line increases. The heat trace selected for this application produces a maximum process tube temperature of approximately 49°C (120°F) at an ambient temperature of -29°C (-20°F).

The calibration gas line heat tracing bundle is composed of approximately 0.8 cm (0.3 inches) of fibrous glass insulation around $\frac{1}{2}$ " x 0.035 wall seamless 316 stainless steel tubing with an electric heat trace lying on top of the tube. The jacket material, installation temperature, and maximum process tube temperature are identical to the specifications for the sample gas line heat tracing bundle.

Various accessories complete the heat trace installation. Included are heat shrink boots to provide a weatherproof end seal for tubing bundles, silicon sealant to seal both ends of the tubing bundle (to be used in conjunction with the heat shrink boots), and jacket patch kits for sealing a splice in a bundle or to extend the insulation.

The portions of the gas lines that are not heat traced or do not use preinsulated, pretraced tubing bundles will be insulated with jacket patch blankets that are made of the same insulation used for the sample gas line and calibration gas line heat tracing bundle. Thermal calculations assume that the insulation for each portion is wrapped to a thickness of 1.3 cm (0.5 inches).

3.6.1.2 Solid State Relay

The solid state relay has a triac output that is controlled by an optoelectronic coupler. It is intended for use as an ON/OFF switch for loads from 0.05 through 25 amps. EMI and RFI are greatly reduced due to zero voltage turn-on and zero current turn-off of the load. The plastic case is UL rated self-extinguishing.

3.6.2 Enclosure Temperature Control

The system enclosure must be environmentally controlled in order to maintain equipment inside the enclosure in an acceptable environment when the following external environment characteristics are possible:

- air temperatures of -29°C to 49°C (-20°F to 120°F)
- relative humidity of 5% to 100%
- wind speeds up to 128 km/hour (80 miles/hour)
- rain, snow, sleet, lightning, blowing dust and sand, and hail
- radiation up to 100 mr/hr.

The components that maintain the equipment inside the enclosure in an acceptable environment are the panel insulation throughout the enclosure, a heater and an air conditioner. The heater is panel mounted inside the enclosure and the air conditioner is mounted on the side of the enclosure.

3.6.2.1 Enclosure

The enclosure containing the Standard Hydrogen Monitoring System is a free standing single door NEMA 4 enclosure. The dimensions are 183 cm X 78.9 cm X 61.1 cm (72.06" X 31.06" X 24.06"). It is designed to house electrical and electronic controls, instruments and components in areas which may be regularly hosed down or are otherwise very wet and is suitable for outdoor applications. Construction is of 12 gauge steel. The seams are continuously welded and ground smooth. The rolled lip around three sides of the door and along top of the enclosure opening excludes liquids and contaminants. The

stainless steel door clamps on three sides of the door assure a watertight seal. Mounting channels are welded horizontally to interior body sides at top, center, and bottom. It has a hasp and staple provided for padlocking.

The enclosure modifications are controlled by drawing H-2-817861, *Standard-B Hydrogen Monitoring System Cabinet Modifications* to include a three point door latch, an externally mounted air conditioner, viewing port, alarm beacons, local alarm horn and control switches and lamps.

3.6.2.2 Enclosure Insulation

The insulation used inside the enclosure is 2.54 cm (1") thick sheet closed cell elastomeric thermal insulation.

3.6.2.3 Enclosure Air Conditioner

The enclosure air conditioner used is a side-mount air conditioner rated at 2000 Btu/hr. It is equipped with an adjustable thermostat for optimal enclosure temperature regulation. Calculations for the air conditioner selection can be found in WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Basis for Air Conditioner Selection".

3.6.2.4 Enclosure Heater

The enclosure electric heater is designed to protect sensitive mechanical, electrical, and electronic equipment from the harmful effects of condensation, corrosion, and low temperature. The heater is thermostatically controlled and the thermostat is adjustable from -18°C to 38°C (0°F to 100°F). The fan draws cool air from the bottom of the enclosure and passes this air across the thermostat and heating elements before being released into the enclosure cavity. Heated air is discharged through the top of the heater unit. Calculations for the heater selection can be found in WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992) Appendix A "Analysis" under "Basis for Heater Selection".

4.0 SYSTEM LIMITATIONS, CASUALTY EVENTS, AND RESPONSE TO CASUALTY EVENTS

Much of the system limitations, casualty events and response to those events was addressed in WHC-SD-WM-DA-078, *The Failure Mode and Effects Analysis of the 241-SY-101 Monitoring System* (Walter 1991). The following items are some possible failure modes, causes, and effects:

BFP-*-1-1: Valve failing to close due to corrosion/deterioration in the seat/plug area. The effect is the failure of the valve to close during a sample line ignition. If the failure was detected, the sample line would be temporarily out of service for repair.

F-*-1-1/2/3: Leakage in the filter hardware may occur due to improper installation or servicing workmanship. The effect is in-leakage, and diluting the sample stream. A system leak check is recommended periodically or whenever the system fittings are opened.

MV-*-*-*: Leakage to the atmosphere may occur due to valve defect or improper installation. The effect is in-leakage diluting the sample, and introducing particulates or moisture. A periodic leak check will discover this problem.

NIT-*-6/12-1: Monitor fails to indicate the percent hydrogen or send the signal indicating percent hydrogen. The cause may be due to instrument circuit or sensor failure. The effect is the loss of the primary hydrogen alarm and sensing capability. Redundant hydrogen sensors and signal conditioning are provided to minimize the impact.

Zero Gas: The hydrogen sensor is calibrated incorrectly due to the incorrect chemical composition in the Zero Gas. The effect is the sample loop being out of service until the problem is identified and resolved. The problem would be identified through a periodic testing of the calibration gas.

Span Gas: The hydrogen sensor is calibrated incorrectly due to the incorrect chemical composition in the Span Gas. The effect is the sample loop being out of service until the problem is identified and resolved. The problem would be identified through a periodic testing of the calibration gas.

PPM Gas: The hydrogen sensor calibration check indicates the wrong value due to the incorrect chemical composition in the PPM Gas. The effect is the discovery of incorrect composition of the calibration gas. The problem would be identified through a periodic testing of the calibration gas.

PCV/MV-*-5-1, PCV/MV-*-5-2, PCV/MV-*-5-3: Valves leak through the seat during the use of other calibration gases. The leakage is due to defects in the valve seats. The hydrogen sensor is calibrated incorrectly due to incorrect composition of the calibration gas. The effect is the sample loop being out of service until the problem is identified and resolved. The problem would be identified through a periodic testing of the calibration gas.

FE-*-7-1: Flow indication is high due to a defective instrument or plugging of the flow element tubes. Lower sensor cell pressure than during calibration can cause a lower than actual concentration reading. If the error is not large there may be no immediate awareness or detrimental effect.

FI-*-3-1: A possible failure mode is the improper indication of flow through the sample cylinders due to a defective instrument. The effect is inaccurate gas grab sample analysis results. This problem may be detected by the operators.

AC Power: A possible failure mode is the loss of incoming power. The effect is system shutdown until the problem is identified and resolved. The problem should be detected by the annunciation of a remote trouble alarm and remote high hydrogen alarm, without local beacon or horn annunciation.

Heat Trace: A possible failure mode is the loss of heat trace due to the loss of control electric power. A temperature controller will detect a low tube temperature and annunciate an alarm.

Enclosure Heating: A possible failure mode is the loss of heating or overheating in the enclosure due to heater or thermostat failure. The performance of the hydrogen sensor and associated instrumentation may deteriorate. A temperature indicator will detect either a high or low cabinet (enclosure) temperature and annunciate an alarm. The air conditioner will attempt to correct the high temperature conditions, with the temperature indicator alarming if unsuccessful.

Enclosure Cooling: A possible failure mode is the loss of cooling in the enclosure due to the air conditioner failure. The performance of the hydrogen sensor and associated instrumentation may deteriorate. A temperature indicator will detect a high cabinet (enclosure) temperature and annunciate an alarm.

P-*-1-1: A possible failure mode is the sample pump stopping due to mechanical damage or the loss of electric power. The low flow alarm will annunciate the loss of sample flow. The effect is the sample loop being out of service until the problem is identified and resolved.

TE-*-14-1: A possible failure mode is no temperature signal being transmitted due to the failure of this element. The fail-safe alarm contacts will annunciate the condition due to the controller burnout circuitry.

TE-*-15-1: A possible failure mode is no temperature signal being transmitted due to the failure of this element. The fail-safe alarm contacts will annunciate the condition due to the controller burnout circuitry.

TE-*-16-1: A possible failure mode is no temperature signal being transmitted due to the failure of this element. The fail-safe alarm contacts will annunciate the condition due to the controller burnout circuitry.

5.0 OPERATION

The operation of the standard hydrogen monitoring system will permit the continual sampling and monitoring of the waste tank gasses for hydrogen, as well as obtaining gas samples for complete gas specie analysis at a remote laboratory. The detailed operating procedures are presented in the Tank Farm Plant Operating Procedure, TO-040-040, *Operate the Standard B or Standard C Hydrogen Monitoring Systems*.

5.1 System Startup

The system initial startup is a major evolution in the system operation. The startup is composed of many subtasks that will be procedurally controlled. The following provides a sequence of events for startup activities.

- A. Perform the system initial valve lineup.
- B. Verify that system power is available.
- C. Set up the enclosure AC and heater thermostats and energize the AC and heater control circuits. Exercise the temperature control adequately to verify that the heater and AC will not operate simultaneously and that there is good temperature control.
- D. Energize each of the powered instruments and verify nominal indications.
- E. Adjust the sample and calibration gas heat trace controller set points. Energize the sample and calibration gas line heat trace power and verify that the line temperatures are controlled to the set point.
- F. Start the sample pump and evacuate the sample system.
- G. Establish a sample flow through the main sample loop.
- H. With grab sample bottles installed in the gas sample assembly, establish the proper flow through the grab sample loop.
- I. Verify that all the process signals are within their nominal range.
- J. Energize, test, and reset the alarm monitoring and control system. Verify that the correct status is indicated based on the current process parameters.

5.2 Perform Hydrogen Monitor Functional Calibration

The two hydrogen monitors will require a functional calibration on a routine basis. The calibration procedure to be used is the Waste Tank Maintenance Engineering Calibration Instruction PSCP-5-025.

5.3 Adjust Heat Trace and Environmental Enclosure Temperature Set Points

The sample and calibration gas heat trace may need to be adjusted slightly for proper temperature control as the ambient temperature changes with the seasons. Once the temperature is established for the coldest season, only minimal adjustments should be required.

Likewise the enclosure temperature set points may need to be adjusted periodically to assure the proper internal temperature. It is important to assure that the heater and AC set points do not overlap.

Additional instructions for these adjustments are included in the troubleshooting sections of Tank Farm Plant Operating Procedure, TO-040-040.

5.4 Grab Sample

Sample gas grab samples may be obtained either through routine operator initiated manual selection or system automatic selection due to exceeding the preset hydrogen alarm trip point during unique tank events. The grab samples will allow a more complete evaluation of the tank gas composition through analysis.

5.5 Leak Check

The sample system shall be leak checked routinely and after any of the fittings or filters have been removed or replaced. The leak check will utilize the sample pump to evacuate the system components, and the system vacuum pressure gauge will be used for the leak evaluation. If the system is found to have a leak, it will be isolated until the leak can be located and repaired.

6.0 MAINTENANCE

The standard hydrogen monitoring system and associated tubing and instrumentation will require routine maintenance to support continual operation. Detailed maintenance procedures cover the general maintenance activities. Some of the maintenance activities, such as main sample flow adjustment and the hydrogen monitor calibrations, may be performed by

operations and maintenance personnel. The following is a general list of maintenance operations.

- A. Calibration of the hydrogen monitor readout and recorder outputs for the high and low range % hydrogen electrochemical cell instrument systems. (NIT-*-6-1 and NIT-*-12-1)
- B. Calibration of the input filter differential pressure indicator. (PDI-*-4-1)
- C. Calibration of the sample line pressure indicator. (PI-*-8-1)
- D. Calibration of the sample line flow transmitter. (FIT-*-7-1)
- E. Operational check of the sample line low flow alarm. (FASL-*-7-1)
- F. Calibration of the strip chart recorder and input channels. (NR-*-6-1 and NR-*-12-1)
- G. Replacement of the strip chart recorder paper.
- H. Draining of or replacement of any of the sample line input filters.
- I. Replacement or cleaning of the air conditioner evaporator cooling air filter.

7.0 REFERENCES

WHC-SD-WM-CR-043, *Design Requirements for a Hydrogen Monitoring System for Tanks 103-SY and 104-AN*, (Groth 1991).

WHC-SD-WM-CR-053, *200 Area Hydrogen Watch List Waste Tank Standard Hydrogen Monitoring System Installation Design Criteria* (Schneider 1994)

WHC-SD-WM-DA-078, *The Failure Mode and Effects Analysis of the 241-SY-101 Monitoring System*, (Walter 1991).

WHC-SD-WM-SDD-001, *Standard Hydrogen Monitoring System System Design Description* (Atencio 1992).

WHC-SD-WM-CSDD-004, *The Family of Standard Hydrogen Monitoring System's Computer Software Design Description* (Bender 1994).

TO-040-040, *Operate the Standard B or Standard C Hydrogen Monitoring Systems* (1994).

APPENDIX A

SUPPORTING DOCUMENTS

WHC-SD-WM-CR-043	<i>Design Requirements and Criteria for a Hydrogen Monitoring System for Tanks 103-SY and 104-AN (BD Groth)</i>
WHC-SD-WM-CR-053	<i>200 Area Hydrogen Watch List Waste Tank Standard Hydrogen Monitoring System Installation Design Criteria (TC Schneider)</i>
WHC-SD-WM-WP-122	<i>Work Plan Hydrogen Monitor for Tanks 103-SY and 104-AN (BD Groth)</i>
WHC-SD-WM-WP-251	<i>200 Area Hydrogen Watch List Waste Tank Standard Hydrogen Monitoring System Installation Engineering Work Plan (TC Schneider)</i>
WHC-SD-WM-SDD-001	<i>Standard Hydrogen Monitoring System, System Design Description (JK Atencio)</i>
WHC-SD-WM-CSDD-004	<i>The Family of Standard Hydrogen Monitoring Systems Computer Software Design Description (RM Bender)</i>
WHC-SD-WM-CSCM-013	<i>Standard Hydrogen Monitoring System Software Configuration Management Plan (T Lopez)</i>
WHC-SD-WM-TP-128	<i>Test Plan for Hydrogen Monitors in Standard Hydrogen Monitoring System (JK Atencio)</i>
WHC-SD-WM-TRP-072	<i>Test Report for Hydrogen Monitors in Standard Hydrogen Monitoring System (JK Atencio)</i>
WHC-SD-WM-TA-034	<i>Technical Assessment of 200 Area Waste Tank Standard Hydrogen Monitoring System Components (TC Schneider)</i>
WHC-SD-WM-DRR-034	<i>Standard Hydrogen Monitoring System Final Design Review Report (TC Schneider)</i>
WHC-SD-WM-ATP-078	<i>Standard-B Hydrogen Monitoring System Acceptance Test Procedure (RM Bender)</i>
WHC-SD-WM-OMM-015	<i>Standard-B Hydrogen System Operation and Maintenance Manual (RM Bender)</i>
WHC-SD-WM-EII-003	<i>Standard Hydrogen Monitoring System, Equipment Installation Instructions (JB Witt)</i>

APPENDIX B

DRAWING LIST

- H-2-87280, *Standard Hydrogen Monitoring System Sample Line Installation*
- H-2-87281, *Standard Hydrogen Monitoring System Heat Trace Details*
- H-2-817851, *Standard-B Hydrogen Monitoring System Piping and Instrumentation Diagram*
- H-2-817852, *Standard-B Hydrogen Monitoring System One Line, Elementary Diagrams*
- H-2-817853, *Standard-B Hydrogen Monitoring System Cabinet Assembly*
- H-2-817854, *Standard-B Hydrogen Monitoring System Wiring Diagram*
- H-2-817855, *Standard-B Hydrogen Monitoring System Interior Panels and Brackets*
- H-2-817859, *Standard-B Hydrogen Monitoring System Instrument Panel Assembly*
- H-2-817860, *Standard-B Hydrogen Monitoring System Loop Diagrams*
- H-2-817861, *Standard-B Hydrogen Monitoring System Cabinet Modifications*
- H-2-818213, *Standard-B Hydrogen Monitoring System P.L.C. Ladder Diagram*
- H-2-818215, *Standard-B Hydrogen Monitoring System Equipment Arrangement*

APPENDIX C

MAJOR COMPONENT LIST

LIST OF COMPONENTS IN THE SAMPLE GAS STREAM:

<u>COMPONENT</u>	<u>DESCRIPTION</u>	<u>VENDOR AND PART NO.</u>
BFP*-1-1	1/2" CHECK VALVE, H200 SERIES	CIRCLE SEALS CONTROLS, 232T-3PP.15
BFP*-1-2	1/2" CHECK VALVE, H3000 SERIES	CIRCLE SEALS CONTROLS, 3008S00T-0.1S
EV*-3-1	1/8" 2 WAY SOLENOID VALVE	ASCO U8225A8V
EV*-3-2	1/8" 2 WAY SOLENOID VALVE	ASCO U8225A8V
F*-1-1	25 MICRON CYCLONE PARTICULATE FILTER	GENERANT, 2S500
F*-1-2	0.2 MICRON HIGH PURITY DEPTH FILTER	MATHESON, 6134-T8FF
F*-1-3	0.2 MICRON HIGH PURITY DEPTH FILTER	MATHESON, 6134-T8FF
FCV*-1-1	1/2" BONNET FLOW CONTROL VALVE	WHITEY, SS-12NKRF8
FE*-7-1	IN-LINE LAMINAR FLOW ELEMENT	MERIAM INSTRUMENT; 50MJ10-10
FI*-3-1	LOW FLOW ROTAMETER	WALLACE AND TIERNAN, 34E096S1XX3
FI*-5-1	PURGE FLOW ROTAMETER	WALLACE AND TIERNAN, 32E083S1XX2
FIT*-7-1	DIFFERENTIAL PRESSURE TRANSMITTER (FLOW)	ROSEMOUNT 3051CD-1A22A1A-B4-E5-M5
MV*-1-1	1/2" SS BALL VALVE	WHITEY, SS-63TS8
MV*-1-2	1/2" SS BALL VALVE	WHITEY, SS-63TS8
MV*-1-3	3/8" SS BALL VALVE	WHITEY, SS-62TS6
MV*-1-4	3/8" SS BALL VALVE	WHITEY, SS-62TS6
MV*-3-3	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-4-1	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-4-2	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-4-3	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-4-4	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-7-1	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-7-2	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-7-3	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-7-4	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV*-8-1	1/4" SS BALL VALVE	WHITEY, SS-62TS4
NE*-6-1	ELECTRO-CHEMICAL HYDROGEN MONITORING CELL	WHITTAKER, 114D038-10
NE*-12-1	ELECTRO-CHEMICAL HYDROGEN MONITORING CELL	WHITTAKER, 114D038-10
P*-1-1	SAMPLE PUMP	PARKER HANNIFIN, MB-302-XP (29678M1)
PDI*-4-1	DIFFERENTIAL PRESSURE INDICATOR	ORANGE RESEARCH INC., 1516 DG-1 C-4.5L
PI*-8-1	PRESSURE INDICATOR	NOSHOK, 45.740-30"Hg

LIST OF COMPONENTS NOT IN THE SAMPLE GAS STREAM:

ACU-*-01	AIR CONDITIONER (2,000 btu/Hr)	McCLEAN MIDWEST, 28-0226-038
BY-*-9-1	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-120
BY-*-10-1	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-120
BY-*-18-1	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-120
BY-*-22-1	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-120
BY-*-23-1	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-120
EB-*-6-1	INTRINSIC SAFETY BARRIER	STAHL, 9001/01-086-150-10
EB-*-12-1	INTRINSIC SAFETY BARRIER	STAHL, 9001/01-086-150-10
F-*-5-1	15 MICRON INLINE FILTER	NUPRO, SS-4FW-15
FASL-*-7-1	DC INPUT LIMIT ALARM	ACTION INSTRUMENTS, 1080-0000
HS-*-19-1	NORMALLY CLOSED PUSHBUTTON SWITCH	ALLEN BRADLEY, 800T-A2D2
HS-*-20-1	NORMALLY CLOSED PUSHBUTTON SWITCH	ALLEN BRADLEY, 800T-A2D2
HS-*-21-1	NORMALLY CLOSED PUSHBUTTON SWITCH	ALLEN BRADLEY, 800T-A2D2
HS/HSL-*-22-1	1NO AND 1NC LIGHTED PUSHBUTTON SWITCH	GENERAL ELECTRIC, 080 SERIES
HS/HSL-*-23-1	1NO AND 1NC LIGHTED PUSHBUTTON SWITCH	GENERAL ELECTRIC, 080 SERIES
HT-*-14-1	SAMPLE GAS LINE AND HEAT TRACE	O'BRIEN, TPE2-B4-B10 (TPE1-B4-B10)
HT-*-15-1	CALIBRATION GAS LINE AND HEAT TRACE	O'BRIEN, TPE1-F2-B10
HTR-*-01	ENCLOSURE HEATER (800W)	HOFFMAN, D-AH8002B
JY-*-14-1	SOLID STATE RELAY	POTTER & BRUMFIELD, SSRT-240D25
JY-*-15-1	SOLID STATE RELAY	POTTER & BRUMFIELD, SSRT-240D25
K-*-01	INTERPOSING RELAY	POTTER & BRUMFIELD, KRPA11AG-240
MV-*-5-1	1/4" SS BALL VALVE	PART OF PCV-*-5-1
MV-*-5-2	1/4" SS BALL VALVE	PART OF PCV-*-5-2
MV-*-5-3	1/4" SS BALL VALVE	PART OF PCV-*-5-3
MV-*-5-4	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV-*-5-5	1/4" SS BALL VALVE	WHITEY, SS-62TS4
MV-*-5-6	1/4" SS BALL VALVE	WHITEY, SS-62TS4
NASH/NASHH-*-6-1	HIGH HYDROGEN ALARM SWITCHES	PART OF NR-*-6/12/SP-1
NASH/NASHH-*-12-1	HIGH HYDROGEN ALARM SWITCHES	PART OF NR-*-6/12/SP-1
NIT-*-6-1	HYDROGEN INDICATING TRANSMITTER	NEWPORT ELECTRONICS, INFU-0-0-1-0-DC1
NIT-*-12-1	HYDROGEN INDICATING TRANSMITTER	NEWPORT ELECTRONICS, INFU-0-0-1-0-DC1
NR-*-6/12/SP-1	3 CHANNEL STRIP CHART RECORDER	JOHNSON/YOKAGAWA, 4153 SERIES
PCV/PI-*-5-1	LOW PRESSURE REGULATOR AND GAUGE	MATHESON 3102-590
PCV/PI-*-5-2	LOW PRESSURE REGULATOR AND GAUGE	MATHESON 3102-350
PCV/PI-*-5-3	LOW PRESSURE REGULATOR AND GAUGE	MATHESON 3102-590
PWR-*-01	24 VOLT DC POWER SUPPLY	ACOPIAN, A24MT210
TASL-*-14-1	TEMPERATURE ALARM SWITCH LOW	PART OF TIC-*-14-1
TASL-*-15-1	TEMPERATURE ALARM SWITCH LOW	PART OF TIC-*-15-1
TASHL-*-16-1	TEMPERATURE ALARM SWITCH HIGH/LOW	PART OF TI-*-16-1

LIST OF COMPONENTS NOT IN THE SAMPLE GAS STREAM:

TE-*-14-1	TEMPERATURE ELEMENT TYPE K T/C	GORDON, AFECOTF720UK100
TE-*-15-1	TEMPERATURE ELEMENT TYPE K T/C	GORDON, AFECOTF720UK100
TE-*-16-1	TEMPERATURE ELEMENT TYPE K T/C	GORDON, AFECOTF120UK100
TI-*-16-1	TEMPERATURE INDICATOR/ALARM	OMEGA, CN9111A
TIC-*-14-1	TEMPERATURE INDICATING CONTROLLER/ALARM	OMEGA, CN9121A
TIC-*-15-1	TEMPERATURE INDICATING CONTROLLER/ALARM	OMEGA, CN9121A
YAH-*-9-1	ALARM HORN	MALLORY, SC110NP
YAL-*-7-1	ALARM LIGHT, (LOW SAMPLE FLOW)	ALLEN BRADLEY, 800T-R10A
YAL-*-10-1	ALARM LIGHT, (TROUBLE)	ALLEN BRADLEY, 800T-R10A
YAL-*-14/15-1	ALARM LIGHT, (HEAT TRACE TEMP. LOW)	ALLEN BRADLEY, 800T-R10A
YAL-*-16-1	ALARM LIGHT, (CABINET TEMP. HI/LO)	ALLEN BRADLEY, 800T-R10A
YAL-*-23-1	ALARM LIGHT, (RESET SAMPLER)	ALLEN BRADLEY, 800T-R10A
YAL-*-10-2	ALARM BEACON, (HIGH HYDROGEN)	EDWARDS, 93R-N5
YAL-*-18-1	ALARM BEACON, (TROUBLE)	EDWARDS, 93A-N5
YYC-*-01	PROGRAMMABLE LOGIC CONTROLLER	TEXAS INSTRUMENTS, 315-AA