PALO VERDE
NUCLEAR GENERATING STATION

Instructor Training

Classroom Lesson

Program: I & C Program	**Technical Review:**
LP Number: NID32C000202	
Title: Explosive Gas Monitor System	**Line Approval:**
Duration : 8 Hours	
Date: 4/30/2008	**Teaching Approval:**
Rev Author: Harry W. Gahagen	

INITIATING DOCUMENTS:

Site Maintenance Training Program Description

REQUIRED TOPICS

NONE

CONTENT REFERENCES

Orbisphere Diagnostic and Service Center Manual

36ST-9GR02 : Gaseous Radwaste Explosive Gas Monitoring System Calibration

74OP-9SS03 : Gaseous Waste System Sampling

TCS 92-0250 : Ends Not Capped When Flow Chamber Removed from O2 Analyzer

TCS 92-0938 : Surge Tank Pressurization After Performing 36ST-9GR01

TCS 92-0563 : GR System O2 Monitor Failed ST

VTM-O115-00001 Vendor Tech Manual for Orbisphere Oxygen Analyzer

Lesson Plan Revision Data

Apr 13, 2008 Harry Gahagen Record created

Tasks and Topics Covered

The following tasks are covered in Explosive Gas Monitor System:

Task or Topic Number*	Task Statement
Lesson:	**Explosive Gas Monitor System**
GR03	Troubleshoot GR system

Total tasks or topics: 1

TERMINAL OBJECTIVE:

1.1 Given the appropriate references,, DESCRIBE the functions, components, and operation of the Explosive Gas Monitor System

1.1.1 STATE the functions of the Explosive Gas Monitor System

1.1.2 DESCRIBE the system to include a basic system description and normal operation

1.1.3 DESCRIBE the major system components of the Explosive Gas Monitor System

1.1.4 DESCRIBE the system flowpath through the Explosive Gas Monitor System

1.1.5 DESCRIBE the Explosive Gas Monitor Analyzer System to include major components and basic system description

1.1.6 USE electrical prints and drawings to, Evaluate the Analyzer loop operations

1.1.7 DESCRIBE a sensor calibration to include microprocessor functions and displays

1.1.8 DESCRIBE the sensor operations to include the theory of operation, components, and operation characteristics

Lesson Introduction: Explosive Gas Monitor System

The following items are things to consider in your Lesson Introduction. They are not mandatory.
You should develop your own introduction and place that material in the Program Hierarchy in the Lesson Introduction Tab or appropriate Training Unit.

CLASSROOM GUIDELINES

- If applicable, remind students of class guidelines as posted in the classroom.
- Pass the attendance sheet around and have it signed in Dark ink.
- Ensure that student materials needed for the class are available for each student.
- Emphasize student participation and remind them of your philosophy on asking and answering questions, if applicable.

ATTENTION STEP

- Give a brief statement or story to get student concentration focused on the lesson subject matter.

LESSON INTRODUCTION

- Give a brief statement that introduces the specific lesson topic. Should be limited to a single statement.

MOTIVATION

- Focus student's attention on the benefits they derive from the training. At Instructor's discretion. The need for motivation in each succeeding lesson must be analyzed by the Instructor and presented as necessary.
- Instructor should include how the STAR process can be used to improve or enhance Operator Performance, if applicable.
- Read and discuss lesson terminal objective and review lesson enabling objectives, if desired.
- If applicable, briefly preview the lesson topic outline and introduce the major points to be covered. The objective review may have been sufficient.
- REINFORCE the following PVNGS management expectations as opportunities become available:

  Nuclear Safety
  Industrial Safety Practices
  STAR and Self-Checking
  Procedure Compliance
  Communication Standards
  ALARA
  Prevent Events

NOTE

Method of instruction will be lecture and discussion of referenced transparencies or slides and handout pages, unless otherwise specified.

NOTE

Before class, ensure your equipment is operable and place the following on the board:
Instructor's Name
Instructor's work phone number
Course name
Course length

*******INTRODUCTION*******

I. Attention Step.

I. Get the attention of the students on you rather than outside interests. Any appropriate means is acceptable.

II. Self Introduction

II. Introduce yourself and present your background and experience, if applicable. This is the best opportunity to have students introduce themselves, if you use this technique to "open up" the class.

III. Classroom Guidelines

III. Refer to the CLASS GUIDELINES at the front of the handout and in front of this lesson plan. Read them or discuss them as applicable to the particular group in your class.

A. Attendance Sheet

A. Pass the attendance sheet around and have it signed in black ink. If applicable, have students add their mail station numbers to the attendance sheet for use when mailing out course certificates. If needed, now is a good time to fill out a seating chart or individual name cards.

B. Materials

B. Ensure that student materials needed for the class are available for each student. For materials required, refer to the list of materials on the cover page. Describe the handout format, if applicable, and stress the importance of taking good notes for future reference, both in the field and for the remainder of the course.

C. Questions and Participation

C. Discuss the importance of participation and your philosophy on asking or answering questions (i.e.,do they need to raise their hand, etc.), if applicable.

IV. Lesson Introduction

A. Topic Introduction

A. Give a brief statement which introduces the specific lesson topic(s).

1. Four functions of the EGM
2. Sampling system description and operation
3. EGM major components
4. System flow path
5. Analyzer system description and major components
6. Tracing through the analyzer electrical loops
7. Sensor calibration
8. Sensor theory of operation, components, and operating characteristics.

B. Motivation

B. Relate the specific lesson topic to the students' future and present needs.

1. Explain that the hazards associated with the Gaseous Radwaste System are carried over to the sampling system
2. The importance of valve line-ups to prevent an unmonitored release

C. Lesson Pre-summary

1. Objectives review

Given the appropriate references, DESCRIBE the functions, components, and operation of the Explosive Gas Monitor System

1. Read and discuss the lesson terminal objective.

2. Topic summary

2. Briefly preview the lesson topic outline and introduce the major points to be covered. The objective review may be sufficient.

T.Obj 1.1	Given the appropriate references,, DESCRIBE the functions, components, and operation of the Explosive Gas Monitor System

EO 1.1.1	STATE the functions of the Explosive Gas Monitor System

1.1.1.1 Main Idea

II. Explosive Gas Monitor System

A. Functions

lecture using power point discuss the Functions of the Explosive Gas Monitor

1. Continuously sample the Gaseous Radwaste System from three designated system components.

2. Provides a continuous sampling from selective components outside the Gaseous Radwaste System

3. Provide an indication of the oxygen concentration and to initiate both, alarm functions and a nitrogen dilution when preset limits are exceeded

4. Provides the capability to obtain a grab sample from any area in which the system is capable of monitoring through the analyzers

EO 1.1.2	**DESCRIBE the system to include a basic system description and normal operation**

1.1.2.1 Main Idea

B. System Overview

Lecture using Power discuss the Sample System

1. Contains four analyzers

Drawing: 02-N-SSP-001

a. Waste Gas Surge Tank

Use 02-N-SSP-001 in conjunction with power point slides and the student handout describe the Sampling System

b. Waste Gas Surge Tank Header

c. Was Gas Decay Tanks

d. Spare - can be connected to the following by means of quick disconnects:

1.) Surge tank, Surge Tank Header or the Decay Tank (Gaseous Radwaste Components)

2.) Volume Control Tank, Reactor Drain Tank, Equipment Drain Tank, Gas Stripper or the Hold Up Tank (Components outside the Gaseous Radwaste System

2. Operability

A Tech Spec Requirement - briefly discuss the requirements

a. Surge Tank and Surge Tank Header analyzers are tech spec equipment

b. Spare can be used to satisfy operability of either Tech Spec analyzer

c. Decay Tank has no special requirements

3. Normal Operations

Lecture using Power Point and the student handout discuss Normal operations. Sampling System

a. Surge Tank, Surge Tank Header and Decay Tank analyzers are in continuous sample

b. Spare is not in service except when a grab sample is taken

4. Cabinets

a. Sample cabinet - receives sample flows, analyzes the sample, and returns the sample to the Gaseous Radwaste System

b. Hood cabinet - provides an enclosed ventilated work area due to the potential hazards from taking grab samples or quick disconnect operations

C. System Description

1. Two major concerns

a. Explosive Potential

1.) Hydrogen is not analyzed for, it is known that there is a sufficient enough concentration to create a potentially explosive atmosphere

2.) Samples are monitored for oxygen to determine if an explosive atmosphere of 4% oxygen by volume exists

3.) Sources of a possible explosive atmosphere are:

a.) Calibration gas of 1 and 4%

b.) Leak into the system at a low pressure point

c.) Leak out of the system at a high pressure point

b. Radiological Potential

1.) Gases stored in the Gaseous Radwaste are gases released form the primary water source

2.) Isotope of major concern is Xe-133 - because of its relative high concentration

c. Prior to beginning any work, checks should be made in the sample room for any hazardous atmosphere

EO 1.1.3	DESCRIBE the major system components of the Explosive Gas Monitor System

1.1.3.1 Main Idea

Describe the system components in the order of the flowpaths

2. Isolation Valves
   a. Two ball valves at the inlet
   b. Calibration connection between the two inlet isolation valves
   c. Packing adjustment - remove the valve handle and tighten the packing bolt clock-wise
3. Regulators
   a. Set for 25 pounds in all four loops
   b. Surge tank and surge tank header will normally be full open because of low system pressure (3 psig) - unless a nitrogen dilution occurs
   c. Decay tanks will be regulate due to the high pressure associated with the tanks
4. Separator/Drains
   a. Removes moisture from the gas samples
   b. Cyclone type - naturally generated centrifugal force separates moisture from the gas sample
5. Filters
   a. Removable Tee type filters
   b. Remove contaminants as small as one-half micron
   c. Filter body need not be removed in order to change the filter

d. Identical filters downstream of the flow switches

6. Pumps

   a. Positive displacement, bellows type, electrically driven, reed valve assembly

   b. Reed valve allows flow through the pump with very little restriction when its not running

   c. Ensure enough flow through the sample loops for a representative sample and minimize the delay time of samples (Low system pressure loops)

   d. Three position handswitch

      1.) OFF

      2.) RUN - pump starts

      3.) ON - pump starts and spring returns to the RUN position

7. Relief Valves

   a. Protect against an overpressure condition

   b. Pump discharge relief valve protects the system in case of an inadvertent isolation downstream of the pump - setpoint of 30 psig and relieves back to the suction

   c. Pump suction relief valve protects against a regulator failure - setpoint of 40 psig and relieves to the surge tank

8. Check Valves

   a. Spring loaded check valves

   b. Prevent reverse flow as well a regulate the output flow from the pumps

   c. Set at 3 psig

9. Flow Indicators

   a. Each loop has three flow indicators - two are located on the front of the sample panel and the third is located inside the panel

b. The front panel indicators display sample flow and bypass flow

1.) Sample flow scale of 0 to 540 cc/min - set at 100 cc/min

2.) Bypass flow scale of 0 to 64,000 cc/min - set to achieve a maximum flow rate through the sample line and still maintain a sample flow of 100 cc/min

c. The third indicator is used in conjunction with an associated flow switch to provide an alarm in the radwaste control room at 30 cc/min

10. Analyzers

a. Consists mainly of a microprocessor and an oxygen sensor which measure oxygen concentration

b. Pressure and temperature compensation required for an accurate indication

c. Pressure sensor is external to the microprocessor and the temperature sensor is internal to the detector

d. Supplies a local indication and a remote indication to a recorder in the radwaste control room

e. Supplies a digital output to the radwaste alarm system and to the auto dilution system

11. Discharge Headers

a. Three possible paths

1.) Per Chemistry procedures, all samples are returned to the surge tank header

2.) All sample returns can be lined up to the surge tank

3.) Surge tank, decay tank, and spare (if used) returned to the surge tank via closed valve V920, and the surge tank header back to the surge tank header line via closed line V919

12. Gas Decay Tank Sample Loop

    a. Gas decay tank sample loop is similar to the surge tank and surge tank header loop except for:

        1.) Three possible sample lines because of three decay tanks

        2.) No pump is required because the tank pressures are high enough to provide adequate flow

13. Spare Sample Loop

    a. Not normally lined up, but can be lined up to the surge tank, surge tank header or the decay tanks

    b. Auto dilution is normally inoperative - put in service by placing the handswitch from OFF to RUN (HS-571 which is identical to the pump switches)

    c. Bypass line around the pump is used when the decay tanks are connected to the spare loop

    d. Can also sample the VCT, RDT, EDT, Gas Stripper or the Holdup Tank (not normally used) - VCT and RDT samples lines are usually used during an outage

    e. Most common function is the taking of grab samples if the surge tank or the surge tank header is inoperable and the spare is not available in accordance with tech spec requirements, or prior to a release from the decay tanks

        1.) Glass sample flask is used and can not handle high pressures

        2.) Two regulators are used - first regulator is set for 25 psig and the

    f. When the spare is used for a backup or during a calibration the second regulator must be set for 25 psig to ensure enough flow (PCV-607)

14. Gas Return Loop

a. Ensures a sample if an auto dilution occurs

b. Auto dilution puts about 60 psig of nitrogen into the surge tank, the sample pumps are rated a 40 psig and can not pump a sample back to the surge tank or surge tank header

c. To protect the sample pumps a gas return pump (P09) is located in the discharge header

1.) Rated at greater than 100 psig

2.) Auto start when surge tank pressure reaches 20 psig increasing

3.) Handswitch HS-586 - the RUN position is the standby condition for the auto start on an increase in surge tank pressure - ON will start the pump and spring return to RUN

15. Hood Exhaust Fan

a. Continually ventilates the hood cabinet to prevent a potentially explosive atmosphere from forming

b. Located on top of the main analyzer panel

c. Handswitch is located on the front of the main analyzer panel (HS-604)

16. Cabinets (J-SSN-E01)

Lecture using Power Point and the student handout discuss the Hood Cabinet - use in conjunction with the Sample System photo.

a. Hood Cabinet

1.) Used to line up other sample sources to the spare loop, take grab samples, and for lining up oxygen and nitrogen for calibrations

2.) Contains the following:

a.) PCV-607

b.) Isolation valves and quick disconnects associated with the grab sample

c.) Nitrogen purge and oxygen calibration tests points

d.) Grab sample and O2 spare analyzer inlet quick disconnect e.) Oxygen and nitrogen purge and calibration isolation valves

f.) Shutoff valves and quick disconnects for the EDT,VCT,RDT, Surge tank, Decay tanks, Holdup tank and the Gas Stripper

17. Main Analyzer Cabinet

Using Power Point and refering to the student handout display the Sampling Cabinet

a. Four analyzers

b. Four regulators

c. Four separator/drains

d. Three sample pumps

e. One gas return pump

f. Twelve flow indicators

g. Four flow switches

h. Filters

i. Relief valves

j. Associated isolation and check valves

k. Hood exhaust fan

EO 1.1.4	**DESCRIBE the system flowpath through the Explosive Gas Monitor System**

EO 1.1.5	DESCRIBE the Explosive Gas Monitor Analyzer System to include major components and basic system description

1.1.5.1 Main Idea

D. Analyzer System

Lecture using Power Point describe Analyzer Components

1. Description

a. Provides analysis, indication and control functions

b. The major component is the microprocessor

1.) Provides a selection of ranges of measurement parameters

2.) Converts electrical signals from sensors into useful information

3.) Provides temperature and pressure compensation

4.) Provides remote output capabilities

2. Components

Lecture using Power Point and refering to the student handout discuss the 3600 Analyzer.

a. Micro: Front Panel

1.) 2 line 16 character LCD per line and foure function control keys

2.) Control Keys

a.) 4 Functions keys; ESC, Up/Down arrow keys and the Enter key.

b.) The ESC key jumps back a step within a program menu. The up down keys are used to scroll through the screen displays. The enter key selects a highlighted item from the menu.

3.) Key operated switch (OFF/LOCKED/ON)

a.) In OFF the micro is deenergized

b.) In ON data can be entered

c.) In LOCKED data entry is disabled

4.) Three program menus are available at the main menu:

b. Micro: Back Panel

Lecture using Power point 3600 Rear View

1.) Inputs

a.) 10 pin sockets for SENSOR 0 (oxygen sensor input)

b.) A 4 pin socket for the pressure sensor which when connected is always in use

c.) The power socket which accepts 110VAC

2.) Outputs

a.) 5 pin socket for a recorder output, which supplies an analog output

b.) 36 pin printer output for standard parallel interface - not used

c.) The RS 232 Jack is actually an external P/S connection point and the P/S is used for external relays.

3.) The micro has a non-volatile or permanent memory

c. Oxygen Sensor

Lecture using Power Point and Vendor handouts discuss the Orbisphere 31120 Sensor

1.) Centrally located, disc-shaped gold oxygen detecting electrode

2.) Connecter must be seated firmly into the SENSOR 0 socket of the micro and the sensor collar attaches to the flow chamber

3.) Sensor components

a.) Sensor membrane

b.) Membrane mask goes over the membrane - with a hole in the center which is the same size as the cathode

c.) Stainless steel membrane holding ring holds both membranes in place

d.) Plastic membrane support ring located underneath the membranes, in which the cathode passes through, and four small holes allowing electrolyte to pass through

e.) Gold cathode which react with oxygen and creates an electric current

f.) Silver guard (which has a cathodic charge on it) prevents stray oxygen within the sensor from reaching the cathode

g.) Silver anode with a positive charge is part of the circuit and is concentric with the other electrodes

Using Power Point and referring to the student handout display the Sensor Wiring Diagram

d. Pressure sensor

Analyzer Components

1.) Compensates for the error which exists between actual and indicated oxygen concentration due to changes in pressure

2.) Supplies a constant input to the micro and is mounted on the flow chamber

e. Temperature sensor

1.) Compensates for change in the membrane permeability due to temperature changes

2.) Located in the sensor head

f. Flow chamber

1.) Designed for two sensors (oxygen and/or hydrogen) and pressure sensor

2.) A stopper and collar are used in place of the hydrogen sensor

3. Operation

a. Analyzer

1.) Flow enters the flow chamber - passes over sensor - develops a current output proportional to oxygen concentration

2.) The micro processes the signals from the oxygen, pressure and temperature sensors

3.) The micro displays the program (WASTEGAS ANALYSIS), oxygen concentration in ppm (at 9,999 ppm %VOL is displayed), and pressure in BAR

EO 1.1.6	**USE electrical prints and drawings to, Evaluate the Analyzer loop operations**

1.1.6.1 Main Idea

b. Recorder loop

Using Power Point - Show the recorder, alarm, and the auto dilution loops

1.) The micro develops a 4 - 20ma analog signal proportional to 0 - 20%VOL sample

Use Power Point and the student handout trace through the recorder loop

2.) Sent to a Foxboro 2AI-I2V card for a 0 - 10VDC output (J-ZRN-C01 - Radwaste Control Room)

Recorder Output Adjustment - after completing the recorder loop description, briefly explain the 4 - 20ma recorder output adjustment

3.) The voltage signal is sent to the recorder via a signal distribution module (SDM-10)

4.) The recorder displays a 0 - 20%VOL scale (There are two recorders - each with two channels)

c. Alarm loop

Analyzer Alarm Loop

1.) Supplies input to Radwaste annunciator and the PMS computer - based on the actual wiring

2.) Four relays supply both functions (K1,K3,K5 and K7)

3.) The analyzer detecting the hi oxygen condition (2%) is wired directly to the window associated with the analyzer detecting the alarm via the relay contacts (6-8)

a.) AIT-571 - COMMON O2 HI (K1)

b.) AIT-577 - GAS DECAY TANK O2 HI (K3)

C.) AIT-583 - GAS SURGE TANK O2 HI (K5)

d.) AIT-588 - GAS SURGE HEADER O2 HI (K7)

4.) All four analyzers share the same PMS point (SSAS5 HI-NORM) thus the four relay contacts (1-3) are wired in parallel

d. Auto dilution loop

Drawing: 02-E-GRB-005

1.) Two separate control functions

Auto Nitrogen Dilution Actuation

a.) Initiates the actual nitrogen dilution

AV-169 Energization

b.) Sends a stop signal to the compressors if running or prevent them from starting if stopped

Use power point slides and refering to the student handout in conjunction with 02-E-RGB-005 to describe the auto dilution loop

2.) Normal conditions

a.) Four relays (K2,K4,K6, and K8), one associated with each analyzer, wired in parallel to K13

b.) K13 serves as an interface and a common junction between the analyzers and the actuation circuit

c.) K2,K4,K6,K8 and K13 are normally deenergized allowing 125VDC to pass through K13-5/8

d.) This allow 125VDC to be applied to relay 62-A which closes contact 62-A-3/5

e.) 125VDC is then applied to relay GRX2 which keeps contact GRX2-21/22 open and ensures that power is not applied to AV-169 solenoid

3.) Auto nitrogen dilution actuation

a.) A 3.75%VOL sensed by any analyzer will initiate an auto dilution

b.) An analyzer senses a hi-hi condition and the associated relay (K2,K4,K6 or K8) will energize and apply 120VAC to K13 relay

c.) K13 energizes, opening contact K13-5/8 and interrupts 125VDC to agastat 62-A

d.) The 62-A relay has a 5 minute time delay deenergization to ensure the hi-hi condition is not due to a spurious or short term condition e.) Spurious conditions can occur from a leak due to taking a grab sample or trace amounts of oxygen in the sample lines after a calibration

f.) Once the agastat times out relay 62-A deenergizes, opening contact 62-A-3/5

g.) 125VDC is interrupted to GRX2 causing contact GRX2-21/22 to close and applying 125VDC to AV-169 solenoid

h.) GRX2 provides two additional functions - alarm signal and the compressor stop signal

i.) The Radwaste alarm is supplied through GRX2-1/2 (AUTO N2 DILUTION O2 HI-HI) - 5 minutes later the Main Control Room receives a trouble alarm (RADWASTE SUMP/PANEL TROUBLE) as well as the PMS point ZRYS1

j.) GRX2 energizes the latching relay GRX3 through contact GRX2-19/20 (GRX3 provides the stop signal to the compressors)

K.) GRX3 latches and stops compressor A through open contact GRX3-1/2 and compressor B through open contact GRX3-7/8

4.) Resetting

a.) When the hi-hi condition clears the majority of the system resets except for GRX3

b.) Power must be applied to GRX3 to reset it

c.) Contact GRX2-7/8 closed when the condition cleared, contact GRX3-6 closed when GRX3 latched d.) All that is required is to place the compressor handswitches (HS-15 and HS-16) to the OFF position thus closing contacts GRX3-1/2 and 7/8

e. Flow switch loop

1.) Notifies the operator if a low flow condition exists in one of the sample loops

2.) Alarms in the Radwaste Control Room (O2 GAS ANALYSIS SYS TRBL) and a red light illuminates on the front panel of the sample cabinet.

3.) Setpoint of 30 cc/min decreasing

EO 1.1.7	DESCRIBE a sensor calibration to include microprocessor functions and displays

1.1.7.1 Main Idea

E. Sensor Calibration

Microprocessor Front Panel - use in conjunction Powerpoint displays and 36ST9GR02.

1. Switch On

   a. Press escape to return to the main menu

   b. Main Menu screen displays :

      1.) Measure,Options, Calibrate

      2.) Press Up or Down until calibrate is flashing

      3.) Then Press enter

2. Press Up or down until extern press is displayed and flashing then press enter.

   Measurement Routine

   a. To change the values press enter.

   b. One point should be displayed and flashing Use Up and Down arrow keys and enter key select One Point cal method.

   c. Press enter key enter correct value ex: 1400mbars.

3. Parameter Measurement

   Parameter Measurement

   a. Press esc to return to the Measure Options calibrate screen

   Parameter Menu - to describe how to obtain a measurement.

   b. Use the Up / down arrow keys select measure and press enter.

   c. Measure as found indicate O2 4%:

      1.) If in tolerance no cal required.

      2.) If Out of tolerance calibrate the sensor.

4. Sensor Calibration

   a.) Turn the keylock switch to Unlock

b.) Press escape until the Measurement Options calibrate appears on the screen.

c.) Press down arrow key to select calibrate then press enter.

d.) Press the up down arrow keys until direct is flashing then press enter.

e.) Enter the known gas (4%) value.

f.) Press enter to view the last calibration data.

g.) Press enter to ensure the screen flashes calibration is complete.

h.) If the screen flashes calibration out of bounds refer to sensor maintenance.

5. Calibrate O2 Sensor — Calibrate O2 Sensor

a. In air

b. Direct calibration

F. Program Flow charts — Functions and Displays : Refer to 3600 VTD and student t handout.

1.) Calibration

2.) Modify Options

3.) Measure Options

1. Calibration menu — Menus

a.) Calibration in air

b.) Calibration direct

c.) Calibration Pressure

1. Barometric pressure — Menus
2. External pressure
3. Pure Hydrogen

2. Modify options — Menus

a. Membrane
1. select membrane

b. Modify options Display Units: — Menus

1.) Gas measurement partial pressure in mbar bar Kpa

2.) Gas measurement dissolved ppb, ppm mg/L

3.) Gas measurement fraction pmv:%V

c. Modify Options Thermal cutoff: Menus

1.) disabled / enables

d. Modify Option Alarms: Menus

1. General Alarm s enable / disable

2. Configure alarms Menus

a. Hi-Hi

b. Hi-Lo

e. Modify Options Analog output

f. Modify Options for Salinity.

g. Modify options for serial output (N/A PVNGS)

h. Modify Options H2 compensation.

i. Modify Options Rolling average

3. Measurement Options: Menus

A . Display gas measured , purge gas and Sensor membrane model number.

B. Display units monitor continuous gas pressure and temperature.

EO 1.1.8	DESCRIBE the sensor operations to include the theory of operation, components, and operation characteristics

1.1.8.1 Main Idea

F. Sensor Description

1. Basic Gas Principles

    a. Sensor actually detects partial pressure

        1.) Air contains a mixture of gases such as nitrogen, oxygen, argon and traces of other gases

        2.) Partial pressure is the pressure a gas would exert if it were the only gas present (in air nitrogen responsible for 78% of the total pressure)

    b. Concentration can be derived by knowing the partial pressure

        Using Power Point slides and referring to the student handout explain the Ideal Gas Law

        1.) P = NRT/V

            a.) P - Pressure

            b.) N - Number of moles

            c.) R - Gas Constant

            d.) T - Temperature

            e.) V - Volume

        2.) Thus N/V = P/RT where N/V equals concentration

    c. When applying gas laws to partial pressure of a gas in a liquid it can be referred to as the fugacity of the gas

d. The solubility of a gas in a fluid is the amount of gas that can be dissolved in the liquid under specific conditions

1.) At equilibrium there is an unchanging proportion between the gas and liquid phase

2.) Components dissolve in the liquid from the gas, and evaporate into the gas from the liquid at the same rate

e. Solubility of oxygen in water is dependent upon:

1.) Pressure

2.) Temperature

3.) Concentration of dissolved salts

f. The concentration of dissolved oxygen depends linearly upon the partial pressure of the gas acting on the surface provided temperature and salt concentration remain constant

g. As temperature increases dissolved oxygen decreases exponentially provided pressure and salt concentration remain constant

h. At constant pressure and temperature, dissolved oxygen decreases as the concentration of dissolved salts increases

2. Basic Theory of Operation

Display the Cathode Reaction

a. In its simplest form is consists of:

1.) Metal anode

2.) Metal cathode

3.) Electrolyte - a solution or liquid which is capable of conducting an electric current by the movement of its dissociated positive and negative ions to the electrodes

4.) An electronic circuit - applied voltage between the anode and cathode to created current flow

b. Cathode reaction — Display the Cathode Reaction

1.) Oxygen penetrates through the membrane dissolves into the electrolyte

2.) Undergoes a reaction at the gold cathode producing an electric current proportional to the oxygen entering the cell

3.) Oxygen concentration is proportional to the oxygen fugacity outside the membrane

4.) $O_2 + 2H_2O + 4e^- \text{--->} 4OH^-$

a.) Oxygen molecule combines with two molecules of water and four electrons

b.) Forms 4 hydroxide ions - the oxygen molecule must be within 1 or 2 molecular diameters from the cathode surface

c. Anode Reaction — Display the Anode Reaction

1.) A loss of 4 electrons at the cathode is compensated for by a supply of 4 electrons from the anode

2.) $4Ag \rightarrow 4Ag^{+} + 4e^{-}$

a.) Silver dissolves into the electrolyte

b.) Four electrons are released to the circuit

d. Electrolyte Reaction | Electrolyte Reaction

1.) Consists of a salt potassium chloride

2.) Reacts with the silver ions to form an insoluble solid thus preventing silver from electroplating to the cathode

e. The fixed voltage supplies a potential to raise the energy of the electrons at the cathode allowing the O2 molecules and 2H2O molecules to react with the electrons

f. Membrane Permeation Rate Factors | Sensor Current Generation

1.) Pressure - the higher the number of impacts at the membrane surface, the higher the number of molecules that pass through the membrane (PO2)

2.) Solubility of oxygen in the membrane (Sm)

a.) Rate of passage depends on the amount of oxygen that is dissolved in the membrane

b.) The higher the specific solubility the higher the permeation rate

3.) Diffusion Coefficient (Dm)

a.) The ease of movement of the gas molecules through the membrane

b.) A higher diffusion rate allow more oxygen molecules to pass through the membrane

c.) Determines the sensitivity and response time of the

4.) Membrane Thickness (Xm) - the thicker the membrane the more resistance it presents to permeation

5.) These factors determine the amount of oxygen entering the sensor per unit of time, and determines the current that will be generated

6.) $$I = \frac{4FA\ Dm\ Sm\ PO2}{Xm}$$

a.) I = Sensor current

b.) 4 = Number of electrons

c.) F = The charge on one mole of singly charged ion

d.) A = Cathode area

g. Current is linearly proportional to oxygen partial pressure, but there are two limits

1.) Upper limit is known as the Ohmic limit

2.) Lower limit is known as the Residual Current

h. Ohmic Limit occurs when the ionic current in the electrolyte produces a voltage nearly equal to the applied voltage

i. Residual Current determines the lowest level of oxygen detectable because of the current generated by sources unrelated to the oxygen sample - some sources are:

1.) Oxygen dissolved in the electrolyte at the time of filling the sensor

2.) Oxygen dissolved in the constructional materials of the sensor, or leaking through mechanical parts

3.) Silver ions electroplating at the cathode from the anode

4.) Secondary electrochemical reactions such as the production of hydrogen gas from the water of the electrolyte

5.) Imperfect electrical insulation between the cathode and anode

6.) Physical characteristics of the membrane and cathode

3. Sensor Components

Display the Sensor Components utilizing Power Point and the student handout.

a. Internals

1.) Anode: silver material

2.) Cathode: Gold material (99.999%) and valve seat

3.) Guard Ring Electrode: silver material

4.) Electrolyte: potassium hydroxide

and potassium chloride in water

5.) Membrane: teflon or tefel

6.) Support Ring: stainless steel

7.) Insulator: sapphire

8.) Membrane Support: plastic

b. Guard Ring

1.) Minimize the residual current caused by:

a.) Oxygen in the electrolyte after electrolysis

b.) Oxygen in the electrolyte after filling the sensor

c.) Oxygen in the constructional material

2.) The residual factors diffuse radially toward the main cathode

3.) The guard ring is placed in the path of, and charged like the main cathode

4.) Guard ring current is sent to ground and not measured

c. Valve, Valve Seat and Insulator

1.) Seals the cathode into the sensor to limit residual current effects

2.) The valve seat prevents the leakage of air between the cathode and surrounding insulator

3.) The valve is spring loaded and forces the insulator and cathode together

4.) The insulator is a sapphire which has the advantage of a stable seal unaffected by heating, cooling, vibration or aging

4. Operating Characteristics

a. Temperature

1.) Temperature increases causes membrane permeability to increase and an indication of O2 concentration will be higher than actual

2.) Compensation is done in the microprocessor using a signal input from the sensor temperature measuring device

3.) Compensation for temperature changes in the process are not required because O2 concentration will not vary in the Waste Gas Tanks as temperature varies

b. Pressure

1.) An increase in pressure means more oxygen passes across the membrane

2.) A pressure sensor produces a signal proportional to sample pressure and sends the signal to the micro for compensation

Give an example and explain pressure increases due to a system addition from a gas addition other than oxygen (nitrogen) and a system addition of pure oxygen

c. Stability

1.) Refers to change in the sensor performance with time, assuming external conditions remain the same

2.) Causes

a.) Chemical change in the electrolyte

b.) Small particles of the anode adhering the cathode

c.) Contamination by external gases

d.) Drying out of the electrolyte

d. Poisoning

1.) Overestimated oxygen level

a.) F_2, Cl_2, Br_2, I_2, ClO_2, SO_3, N_2O_3 and O_3 are indistinguishable from oxygen by the sensor

b.) SO_2 and H_2S are active at the silver anode and can

c.) NH_3 and ethylene diamine can form soluble complexes with silver ions and can shift the potential

d.) HCl and NO_2 cause the electrolyte to become acidic and cause hydrogen evolution at the cathode

2.) Underestimated oxygen level - substances reacting with the gold cathode like HCN react with the gold surface and interfere with the oxygen reaction

III Lessons Learned TCS 92-0250

A. Ends Not Capped When Flow Chamber Removed From 02 Analyzer.

1. AE-571 continued to leak at pipe fittings.

2. Chemistry was notified that during sampling, the room would become gassed up.

3. System would be isolable if the line was plugged when the cell was removed.

4. Following day the cell was removed to be reworked at the hot machine shop.

5. The plug was not installed by the tech because:

    a. System was out of service.

    b. Short time for the fix.

6. Engineer contact chemistry they could take samples, but to contact him first.

7. Later, chemistry took a sample whithout notifying the engineer.

8. RU-15 alarmed, sample secured.

B. Surge Tank PressurizationAfter Performing 36ST-9GR01 — TCS 92-0938

1. Caused by an alarm on the Surge Tank channel.

2. The cause of the alarm, therefore subsequent auto dilution, was low (zero) flow through the monitor.

3. The alignment resulted from the performance of 36ST-9GR01.

4. Restoration steps left the system aligned for auto dilution with no flow through the monitors prior to Chemnistry returning the system to service.

5. While attempting to restore the system after the dilution, damage to the Surge Tank sample pump occurred.

6. The pump sensed 110 psig, designed for 25 psig max.

7. Resolutions

   a. Change 36ST-9GR01 and GR02 to leave auto dilution deactivated during restoration.

   b. Preclude pump operation while system pressure is high.

C. GR System O2 Monitor Failed ST — TCS # 92-0563

1. Event Evaluation

   a. The GR system O2 Analyzers have failed their monthly functional checks on a number of occasions. Typically, a complete calibration is required prior to returning the O2 analyzers to service.

b. The initial expectations were that this complete calibration would only be required on a quarterly interval. These fucntional check failures result in a significant expenditure of maintenance resources and manpower.

c. This condition has been evaluated by a multi-department task force. During teh meeting of this task force "working solutions" were reviewed and refined.

d. The working solutions involved using the Unit 1 system for installing the solutions developed, and monitoring "in-service" system performance prior to making the system "operable" and expanding the validated solutions to the other units. The solutions developed include:

1) disassembly of flow chambers and obtaining as found data,

2) rebuilding O2 sensor using improved "screw on" pressure cap with an alternate grill and gortex pad for better pressure and moisture control,

3) calibration of the O2 sensor using methods developed to isolate teh flow chamber and reduce calibration variables,

4) installation of the flow chambers with an enhanced orientation for sensor performance,

5) placing the system in service without declaring teh analyzers "operable" and collecting daily performance data for a period of 30 days,

6) evaluating the performance data to see if solutions are validated and a

basis has been obtained for declaring the system operable.

e. The task force also agreed that the ST should be streamlined to allow the completion of discrete portions of the calibration as opposed to performing the entire calibration.

2. Apparent Root Causes

a. the original installlation has deficiencies,

c. the procedure is not "user-friendly",

d. the probes have not performed as expected either due to the need for enhanced maintenance practices/procedures or unreasonable expectations.

3. Corrective Actions

a. The working solutions have been installed in Unit 1

b. Daily data collection by Chemistry completed

c. A System Engineer "position paper" was issued to outline the problems/solutions being considered

d. Revise 36ST-9GR02 to improve methodology and make "user-friendly"

e. Validate data gathered and system performance via EER 91-SS-031

I. Summary of Main Principles

A. Objectives review

A. Review the lesson enabling objectives

1. STATE the functions of the Explosive Gas Monitor System
2. DESCRIBE the system to include a basic system discription and normal operation
3. DESCRIBE the major system components of the Explosive Gas Monitor System
4. DESCRIBE the system flowpath through the Explosive Gas Monitor System
5. DESCRIBE the Explosive Gas Monitor Analyzer System to include major components and a basic system description
6. USE electrical prints and drawings to evaluate the Analyzer loop operations
7. DESCRIBE a sensor calibration to include microprocessor functions and displays
8. DESCRIBE the sensor operations to include the theory of operation, components and operation characteristics

B. Topic review

B. Restate or review the main principles or ideas covered in the lesson

1. System functions
2. Basic system description
3. System components
4. System flowpaths
5. Detailed analyzer system description
6. Detailed sensor description

II. Questions and Answers

A. Oral questions	A. Ask questions which implement the objectives. Discuss students' answers as needed to ensure the objectives are being met.
III. Problem Areas	III. Review any problem areas discovered during the oral questioning. Use this opportunity to solicit final questions from the students (last chance).
IV. Lessons Learned	IV. Read or have the students read applicable SER's, EER's, etc.; especially those which deal with PVNGS. Have students discuss the reports and decide what actions were incorrect, and what actions should have occurred.
V. Concluding Statement	V. Review the motivational points which apply this lesson to the students' future and present needs. Use this opportunity to address an impending exam.

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.