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June 9, 1983

BECO Letter No. 83-145

Mr. Domenic B. Vassallo, Chief  
Operating Reactors Branch #2  
Division of Licensing  
Office of Nuclear Reactor Regulation  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

License No. DPR-35  
Docket No. 50-293

Subject: Design Details of NUREG 0737 Item II.F.1.6 Containment Atmospheric Monitor.

Reference: Telecon, K. Eccelston (NRC) and T.M. Thurston (BECO), April 11, 1983.

Dear Sir:

As requested by Mr. K. Eccelston of your office, Boston Edison is furnishing, via the Attachment, our design detail description for the subject NUREG item.

Boston Edison plans to complete this task by June 1, 1984.

We trust this information is responsive to your needs. However, should you have any questions, please contact us.

Very truly yours,

*W.D. Harrington*

Attachment (13 pages)

## Attachment (13 pages)

### Summary

The H<sub>2</sub>/O<sub>2</sub> System has been designed to provide continuous "on-line" monitoring of the hydrogen and oxygen concentrations within the Primary Containment atmosphere (both torus and drywell). The H<sub>2</sub>/O<sub>2</sub> System is a safety related system and is required to monitor potential combustible gas mixtures within the Primary Containment following postulated loss of coolant accidents (LOCA).

Operation of the O<sub>2</sub> portion of the system during plant operation will satisfy the Technical Specification requirements related to the monitoring of containment O<sub>2</sub> concentration during power operation. The H<sub>2</sub>/O<sub>2</sub> System consists of two redundant safety trains, each of which can independently fulfill the safety related functions of the system. Each safety train includes an analyzer panel, a Reagent Gas Subsystem and the necessary valves, piping, and tubing to transport the containment atmosphere sample to and from the analyzer panels. Each safety train is capable of taking samples from four locations (approximately EL 70', 67', 37', and 16' 9") within the drywell and two locations (approximately 180° apart at EL 14' 3") within the torus. A common Calibration Gas Subsystem to both safety trains is provided for periodic calibration of the analyzers.

The analyzer panels for both trains are located on the 74' 3" elevation in the Reactor Building where local control of the system can be performed. A remote control station for each train is also provided in the Control Room in panels C-174 and C-175.

Each train of the H<sub>2</sub>/O<sub>2</sub> System is capable of monitoring oxygen and hydrogen concentrations with a maximum range of 0-20 +.2% for hydrogen and 0-25 +.5% for oxygen concentrations. Readouts are provided locally at the analyzer panels and remotely in the Control Room at panels C-174 and C-175. High hydrogen concentration alarms, high oxygen concentration alarms, and strip chart recorders are also displayed on the Post Accident Monitoring (PAM) panels located in the Control Room (Panel C-170 and C-171).

## SYSTEM DESIGN

### Detailed Design Description

#### General

The H<sub>2</sub>/O<sub>2</sub> System has been designed to obtain, analyze, and provide indication (locally and in the Control Room) of hydrogen and oxygen concentrations within the Primary Containment. The system has been designed for operation during normal plant operation and during postulated LOCA conditions. The system provides "on-line" monitoring of H<sub>2</sub>/O<sub>2</sub> concentrations through a maximum range of 0 to 20% and 0 to 25%, respectively.

The H<sub>2</sub>/O<sub>2</sub> System is comprised of two sample and analyzer trains. Each train consists of an analyzer panel, Calibration Gas and Reagent Gas Subsystems, and associated valves and piping for sample supply and return lines. Each train is independent, and redundant with the exception of a Calibration Gas Subsystem which is common to both trains.

NOTE: The Primary Containment penetrations utilized by the H<sub>2</sub>/O<sub>2</sub> System are currently used by the existing H<sub>2</sub> and O<sub>2</sub> Analyzers Systems. The installation of the new H<sub>2</sub>/O<sub>2</sub> System will therefore render these lines inoperable for the existing H<sub>2</sub> and O<sub>2</sub> Analyzers.

#### Gas Sample Supply and Return Lines

The H<sub>2</sub>/O<sub>2</sub> System is designed to provide "in-line" analysis of the H<sub>2</sub> and O<sub>2</sub> concentrations in the Primary Containment. In the analyze mode, a Primary Containment atmosphere sample is drawn from the Primary Containment (either drywell and torus) and is returned to containment after passing through the analyzer panel. All sample supply lines are electrically heat traced and insulated to maintain the sample temperature greater than 275°F to prevent condensation of steam in the sample lines. In addition all sample supply lines are continuously sloped away from the analyzer panels to allow drainage. All sample return lines are sloped from the analyzers to allow condensation to drain from the analyzer panels.

The locations of these sample supply and return lines are as follows:

#### 1. Drywell Atmosphere Sample Lines

Each train of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining drywell atmosphere samples from two separate locations.

Train A of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining drywell atmosphere samples via existing penetrations X-29E and X-106A-b, and the associated containment isolation valves SV-5065-33A and 37A, and SV-5065-14A and 21A, respectively. Penetration X-29E is currently the sample location for the existing H<sub>2</sub> Analyzer System, and penetration X-106A-b is currently a sample location for the exist-

ting O<sub>2</sub> Analyzer System. The above containment isolation valves will replace existing containment isolation valves CV-5065-33 and 37, and CV-5065-14 and 21, in the H<sub>2</sub> Analyzer and O<sub>2</sub> Analyzer Systems, respectively.

NOTE: Penetration X-29E will provide a common drywell atmosphere sample location with the Post Accident Sampling System. The PASS will tie-in to this sample line outside the H<sub>2</sub>/O<sub>2</sub> System containment isolation valves. Penetration X-106A-b will provide a common drywell atmosphere sample location with the C-19 Panel. The C-19 Panel will tie-in to this sample line, downstream of H<sub>2</sub>/O<sub>2</sub> System containment isolation valves.

Train B of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining drywell samples via penetrations X-15E and X-50A-d and the associated containment isolation valves SV-5065-31B and 35B, and SV-5065-13B and 20B, respectively. Penetration X-15E is currently a sample location for the existing H<sub>2</sub> Analyzer System, and penetration X-50A-d is currently a sample location for the existing O<sub>2</sub> Analyzer System. The above containment isolation valves will replace existing containment isolation valves, CV-5065-31 and 35, and CV-5065-13 and 20, in the H<sub>2</sub> Analyzer and O<sub>2</sub> Analyzer Systems, respectively.

NOTE: Penetration X-50A-d will provide a common drywell atmosphere sample location with both the PASS System and C-19 Panel. The PASS and the C-19 sample piping will tie-in to this sample line, downstream of the H<sub>2</sub>/O<sub>2</sub> System containment isolation valves.

### Torus Atmosphere Sample Lines

Each train of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining a torus atmosphere sample at one location.

Train A of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining a torus atmosphere sample via penetration X-228J and containment isolation valves SV-5065-11A and 18A. Penetration X-228J is currently a sample location for the existing O<sub>2</sub> Analyzer. The above containment isolation valves will replace existing containment isolation valves, CV-5065-11 and 18, in the O<sub>2</sub> Analyzer System.

NOTE: Penetration X-228J will provide a common torus atmosphere sample location with the PASS. The PASS will tie-in to this sample line downstream of the H<sub>2</sub>/O<sub>2</sub> System containment isolation valves.

Train B of the H<sub>2</sub>/O<sub>2</sub> System is capable of obtaining a torus atmosphere sample via penetration X-228C, and containment isolation valves SV-5065-15B and 22B. Penetration X-228C is currently a sample location for the existing O<sub>2</sub> Analyzer System. The above containment isolation valves will replace existing containment isolation valves CV-5065-15 and 22 in the O<sub>2</sub> Analyzer System.

NOTE: Penetration X-228C will provide a common torus atmosphere sample location with the PASS System. The PASS will tie-in to this sample line, downstream of the H<sub>2</sub>/O<sub>2</sub> System containment isolation valves.

## Sample Return Lines

Sample returns for each train of the H<sub>2</sub>/O<sub>2</sub> system go to separate locations. Train A returns the samples (either drywell or torus sample) to the drywell, and Train B returns to the torus.

The Train A atmosphere samples are returned to the drywell via penetration X-46F, and containment isolation valves SV-5065-24A and 26A. Penetration X-46F is currently the sample return line to the drywell for the existing O<sub>2</sub> Analyzer System. The above containment isolation valves will replace existing containment isolation valves, CV-5065-24 and 26, in the O<sub>2</sub> Analyzer System.

NOTE: Penetration X-46F will provide a common sample return location with the PASS System. The PASS will tie-in to this return line, upstream of the H<sub>2</sub>/O<sub>2</sub> system containment isolation valves.

The Train B atmosphere samples are returned to the torus via penetration X-228K, and containment isolation valves SV-5065-25B and 27B. Penetration X-228K is the sample return line to the torus for the existing O<sub>2</sub> Analyzer System. The above containment isolation valves will replace existing containment isolation valves, CV-5065-25 and 27, in the O<sub>2</sub> Analyzer System.

NOTE: Penetration X-228K will provide a common sample return location with the PASS System. The PASS will tie-in to this return line piping, upstream of the H<sub>2</sub>/O<sub>2</sub> System containment isolation valves.

## H<sub>2</sub>/O<sub>2</sub> Analyzer Panels

### 1. General

Each train of the H<sub>2</sub>/O<sub>2</sub> System is provided with an H<sub>2</sub>/O<sub>2</sub> Analyzer Panel located on the 74' 3" elevation in the Reactor Building. The panel receives sample flow from the appropriate sample point. After analysis, the sample is returned to the Primary Containment via the sample return line. The analyzer panels for each train are functionally identical.

### 2. Analyzer Operation

#### A. Thermal Conductivity Cell Operation

The H<sub>2</sub>/O<sub>2</sub> Analyzer takes advantage of the difference in thermal conductivity of various gas species to measure gas concentrations. For example, the thermal conductivity of hydrogen (at the temperatures utilized in the analyzer) is approximately seven times that of nitrogen, oxygen, and water vapor (the only gasses expected to be in the containment atmosphere in significant quantities).

To measure the thermal conductivity of the gas sample, the analyzer uses a self-heating filament within a temperature controlled metal cavity. The temperature of this filament is directly affected by the rate which heat is conducted from the filament through the sample gas to the cavity

wall. Because the cavity wall is maintained at a constant temperature, the filament temperature is only a function of the thermal conductivity of the sample gas. The electrical resistance of the self-heating filament is a function of its temperature; therefore, the resistance of the filament is a function of the thermal conductivity of the sample gas yielding an electrical output indicative of the thermal conductivity of the gas.

#### B. Hydrogen Concentration Measurements

Hydrogen concentration measurements are made by two thermal conductivity cells; a reference cell and a measuring cell. Both cells are essentially identical except that the reference cell includes a catalyst which causes the hydrogen in the sample stream to combine with oxygen to form water vapor.

To measure hydrogen concentrations, the sample gas passes through the measuring and reference cells. The lack of hydrogen in the reference cell (caused by the catalytic reaction within the reference cell) causes a mismatch between the electrical resistances of the self-heating filaments (i.e., the difference in thermal conductivity of the gases). The filaments are connected across an electrical bridge which yields an output indicative of the percentage of hydrogen gas present.

The above process assumes that sufficient oxygen is available in the air sample to assure the complete reaction of all hydrogen within the reference cell. This condition may not always exist within the containment atmosphere.

Therefore, a reagent gas (essentially 100% O<sub>2</sub>; see Reagent Gas Subsystem) is added to the sample stream upstream of the analyzer cells. A sufficient amount of reagent gas is added to assure the complete reaction of hydrogen within the reference cell over the maximum range of the analyzer, assuming no oxygen is present in the containment atmosphere.

#### C. Oxygen Concentration Measurements

The oxygen analyzer functions essentially the same as the hydrogen analyzer however in this case, the reagent gas is essentially 100% hydrogen. The lack of oxygen in the reference cell (caused by the catalytic reaction) when compared to the presence of oxygen in the measuring cell yields an analyzer output indicative of the percentage of oxygen in the sample gas.

### 3. Calibration Modes

The analyzer cell operation described above provides an electrical output indicative of the relative difference between the thermal conductivities in the reference and measuring cells.

To relate this relative difference in thermal conductivities to actual concentrations of the sample being analyzed, the output of the analyzer cells must be calibrated. To calibrate the analyzers, two calibration modes are

provided, zero mode and span mode. Both modes utilize a calibration gas (see Calibration Gas Subsystem) which supplies a known percentage of gas being analyzed (4% hydrogen for the hydrogen analyzer and 7% oxygen for the oxygen analyzer).

#### A. Zero Mode

The purpose of the zero mode in calibration is to balance the outputs of the measuring cell and reference cell to yield a zero output when no differences in thermal conductivity exists between the cells. In this mode, only the calibration gas passes through the analyzer. Because the reagent gas is not supplied to the analyzer, no catalytic recombination will occur in the reference cell, causing both cells to measure identical thermal conductivities. This is the case when the actual sample stream contains zero percent hydrogen or zero percent oxygen for the hydrogen and oxygen analyzers, respectively. The electrical output of the analyzers are therefore adjusted to indicate a zero percent concentration.

#### B. Span Mode

The purpose of the span mode is to adjust the electrical output of the analyzers to be proportional to the percentage of the gas being analyzed. In this mode, both the calibration and reagent gases are allowed to pass through the analyzers. Because the reagent gas is being supplied, catalytic recombination will occur in the reference cell yielding a difference in thermal conductivity. Because the percentage of hydrogen for the hydrogen analyzer calibration gas and the percentage of oxygen for the oxygen analyzer calibration gas is known, the electrical output of the analyzers can be adjusted to indicate this known percentage.

### 4. Overall Panel Operation

Train A and Train B are functionally identical. Train A will be discussed. In the sample mode, the sample gas enters the analyzer panel, passes through an insulated line, through a bellows seal valve, and into a heated sample compartment (hot box). A local pressure indication is provided on this line. In the hot box, the sample flows into a moisture separator. This moisture separator consists of the float operated valve that shuts off flow to the analyzer sections of the panel if the separator is unable to handle the liquid load. This condition may occur during initial system startup or after failure of the heat tracing on the sample supply lines. The condensate from the moisture separator enters the analyzer bypass line and is returned to the containment via PCV-R2-5140A and the analyzer panel sample pump. The analyzer bypass line is provided to allow the analyzer pump to be operated at essentially a constant flow condition. When vacuum in the line is reduced below -11" to -13" Hg, PCV-R2-5140A opens bypassing sufficient sample flow to allow the pump to operate at maximum total sample flow. Flow indicator FI-1-5127A is located on this line. Normal bypass flow is 9 to 18 scfh. Bypass flow and the return flow from the analyzer section of the panel, combine, and pass through an air cooled heat exchanger. This heat exchanger reduces sample temperature to 175°F or less to extend the life of the sample pump diaphragms.

The total sample flow from the analyzer exits the sample pump, passes through a bellows seal valve and is returned to the containment via the sample return line.

Sample flow to the analyzer section of the panel is regulated via PCV-R1-5126A. Regulator PCV-R1-5126A operates to maintain a downstream vacuum of 0" to -5" Hg. Downstream of PCV-R1-5126A, sample flow passes through the H<sub>2</sub> and O<sub>2</sub> thermal conductivity cells AE-1-5074A and AE-2-5035A. Some of the flow is bypassed to the sample pump to maintain the proper flow conditions through the analyzers. The bypass flow can be monitored via FI-1-5078A.

The function of both the hydrogen and oxygen analyzer legs and associated calibration and reagent gas legs are identical. The following description is for the hydrogen analyzer but is typical for both analyzers.

The Calibration and Reagent Gas Subsystems tie-in to the analyzer leg upstream of the analyzer cell. These gases enter the analyzer panel through solenoid operated valves SV-1-5065A and SV-2-5172A. These solenoid operated valves isolate the calibration and/or reagent gas supply to the analyzer leg depending on the mode of operation of the panel (i.e., sample, zero, or span modes). Pressure switches PS-1-5173A and PS-2-5172A are included on these lines. These pressure switches are set to alarm when either gas supply drops below 20 psig. Pressure control valves (PCV-1-5129A and PCV-2-5066A), flow indicating controllers (FIC-1-5310A and FIC-2-5180A), and check valves are located downstream of the solenoid operated valves.

The pressure control valves are factory adjusted and maintain a constant differential pressure of approximately 3 psid across the flow indicating controls.

The flow indicating controllers allow adjustment of the calibration and reagent gas flow rates. Check valves are provided in the lines to separate the calibration and reagent gas lines from the analyzer legs.

The analyzer cell is located downstream of the calibration and reagent gas tie-in points. Analyzer cell flow is regulated by a differential pressure regulator, PCV-R3-5075A, and a fixed orifice, FO-1-5090A. PCV-R3-5075A is factory adjusted to provide approximately 3 psid differential pressure across the fixed orifice.

The fixed orifice is sized to provide a flow of approximately 120 to 200 cc/min through the analyzers. Flow indicator FI-2-5114A is provided downstream to indicate analyzer flow. A vacuum switch, PS-5-5412A, is located between PCV-R3-5075A and the fixed orifice. This vacuum switch is provided to initiate an alarm in the event of fixed orifice blockage, sample pump vacuum loss, or sample exit blockage.

### Reagent Gas Subsystems

As described above, the H<sub>2</sub>/O<sub>2</sub> analyzers require a reagent gas supply of essentially 100% O<sub>2</sub> and H<sub>2</sub> gas to aid in the analysis for H<sub>2</sub> and O<sub>2</sub> concentrations, respectively. A Reagent Gas Subsystem is provided for each train.



Each Reagent Gas Subsystem consists of two compressed gas cylinders (99.9% H<sub>2</sub> and 99.9% O<sub>2</sub>), a compressed gas bottle rack, pressure regulating/relief valves for each bottle, and associated manual valves and tubing to supply the reagent gas to the analyzer panels. The reagent gas bottles and associated bottle racks are located on the 74' 3" elevation within the Reactor Building. The Reagent Gas Subsystems are also provided with auxiliary fill connections located outside the Reactor Building (Secondary Containment). The auxiliary fill connections are provided to allow recharging of the reagent gas bottles during accident conditions when it is assumed that the Reactor Building will be inaccessible.

Calibration Gas Subsystem

The Calibration Gas Subsystem is similar to the Reagent Gas Subsystems, except that only one train is provided common to both analyzer panels. The Calibration Gas Subsystem consists of two compressed gas bottles (4% H<sub>2</sub> and 7% O<sub>2</sub>), bottle racks (the calibration gas bottles use the sample bottle racks provided for the Reagent Gas Subsystems), pressure regulator/relief valves for each bottle, and associated valves and tubing to supply calibration gas to the analyzer panels. As in the case of the Reagent Gas Subsystems, the Calibration Gas Subsystem is provided with auxiliary fill connections located outside the Reactor Building to allow recharging of the calibration gas bottles during accident conditions when the Reactor Building may be inaccessible.

Major Component Design

H<sub>2</sub>/O<sub>2</sub> Analyzer Panel

The following information is provided.

Panel Dimensions:	<u>L x W x H</u>
Analyzer Panel	30" x 30" x 72"
Remote Panel	20 3/8" x 19" x 17 1/2"
Panel Weights:	
Analyzer Panel	1600 pounds
Remote Panel	75 pounds
Normal Panel Environmental Limits:	
Temperature	40 to 120°F
Pressure	27.92" Hg to 31.92" Hg
Humidity	0 to 95%
Radiation	0 to 10 <sup>6</sup> Rads (total)

Normal Sample Environmental Limits at the Analyzer Panel:

Temperature	270 to 300°F
Pressure	-5 to 60 psig
Humidity	0 to 100%
Radiation	0 to 10 <sup>6</sup> Rads (total)
System Response Time:	60 seconds (maximum)
System Warm-up Time:	
"Off" to "Analyze" position	6 hours
"Standby" to "Analyze" position	60 seconds
Power Requirements:	120 VAC + 10%, 60 Hz, + 10%, 9A 460 VAC, 60 Hz, 3 phase, 1.70 FLA

Instrumentation and Control

Parameters to be Controlled and Displayed

1. Main Control Room Panel C-904

- 8 Drywell sample line containment isolation valves
- 4 Suppression Pool sample line containment isolation valves
- 1 Drywell sample return line containment isolation valve
- 2 Suppression Pool sample return lines containment isolation valves
- Valve position indication for the above valves
- Containment isolation signal Override for the above valves.

2. Main Control Room Panels C-170 and C-171

- Isolation Signal Override Alarm
- % H<sub>2</sub> Recorder
- % O<sub>2</sub> Recorder
- Sample Location
- High H<sub>2</sub> Alarm
- High O<sub>2</sub> Alarm

### 3. Main Control Room Panels C-174 and C-175

- Sample controls and Indication of Sample Line being analyzed.
- % H<sub>2</sub> and % O<sub>2</sub> Indication
- Alarms for High H<sub>2</sub> and High O<sub>2</sub>
- Control for Power, Local-Remote selection, function selection, Range selection, Alarm reset.
- Status Indication for Heater ON, Power ON, Span, Zero, sample, H<sub>2</sub> Range 1, H<sub>2</sub> Range 2, High H<sub>2</sub>, O<sub>2</sub> Range 1, O<sub>2</sub> Range 2, High O<sub>2</sub>, Common Failure

### 4. Local H<sub>2</sub> and O<sub>2</sub> Analyzer Panel

- Local Remote Controls
- Function Selection
- % H<sub>2</sub> and O<sub>2</sub> Indication
- Alarm Reset
- Status Indication: Heater ON, Span, Zero, Sample, H<sub>2</sub> Range 1 or 2, High H<sub>2</sub>, O<sub>2</sub> Range 1 or 2, High O<sub>2</sub>, Power ON, Standby, Cell Failure, Low Flow, Low Temperature Low Press, and Common Failure

A 4-20 MA output signal is supplied to the Main Control Room for recording of oxygen and hydrogen concentrations. An indication to identify which of the three samples is being analyzed, is shown locally and in the Control Room. This signal has three signal levels within the span of 4-20 MA.

#### Analyzer Operating Range

0-10 $\pm$ .2%	Hydrogen
0-20 $\pm$ .2%	Hydrogen
0-10 $\pm$ .2%	Oxygen
0-25 $\pm$ .5%	Oxygen

#### Electrical Power Systems

The H<sub>2</sub>/O<sub>2</sub> Systems being installed are two completely redundant H<sub>2</sub>/O<sub>2</sub> analyzer instrument racks, identified as C-172 JJC and C-172 JJC and located at elevation 74' -3" of the Reactor Building (Secondary Containment). The output of each analyzer feeds a JJC 19" insert in the Post Accident Sampling Panels C-174 and C-175 in the Main Control Room. These inserts provide controls necessary for remote control of the analyzers and they also provide transducers which are required to drive the various devices used to monitor the H<sub>2</sub>/O<sub>2</sub> concentration. In addition, alarm lights are located on the analyzers and the C-174/C-175 inserts. Annunciation points (non-safety related) are provided on panels C-170 and C-171.

Each analyzer requires 460 v, 3 phase and 120 v single phase power. The Division I analyzer receives its 460 v supply from safety related MMC B17A cubicle 17A13A and its 120 v power from distribution panelboard Y13 breaker #2. The Division II analyzers receive power from the redundant safety related sources MCC B18A cubicle 18A13A and panelboard Y14 breaker 2.

Each sample and sample return line has two solenoid operated valves piped in series and located as close as possible to the primary containment. Electrically, the solenoids are designed to operate at 120 VAC (outboard) or 125 VDC (inboard). The valves draw 1.5 Amps maximum at rated voltage. The valve position switches are reed type SPST with contacts rated for .5 Amps at 125 VDC. The position switches and coil pigtails are wired to terminal blocks inside a NEMA 4 enclosure where all incoming field cables are terminated.

Except for valves requiring heat tracing, the solenoids are designed to pickup and remain energized between 96 and 132 volts for the AC valves and 90 and 140 volts for the DC valves. Those valves requiring heat tracing have a "control box" in series with the coil of the solenoid. The "control box," which consists of a time delay relay and a voltage dropping resistor, allows the valves to be picked up at rated voltage and "held in" at reduced voltage. The reduced voltage lowers the heat generated in the solenoid housing thus reducing the total temperature around the coil and increasing the life expectancy of the valve. The "control boxes" are located in control panels located in the Main Control Room.

Each series pair of isolation valves is controlled from panel C-904 and receives power (DC inboard and AC outboard) from the same Division of Class IE Electrical Distribution System as its associated analyzer panel. Valves in the redundant sample/return lines receive power from the second independent Class IE Power Distribution System. Power to the DC valves is obtained from panelboards D36 breaker 3 (Div. I) and D37 breaker 3 (Div. II). Power required for the AC solenoid valves is obtained from Class IE panelboards Y31 breaker 1 (Div. I) and Y41 breaker 1 (Div. II).

Each valve is closed by a containment isolation signal (low reactor water level/high drywell pressure) obtained from multipliers of General Electric containment isolation logics. Division I isolation signals are used for inboard isolation valves and Division II signals are used for outboard valves.

The isolation signals can be overridden by the operator via operation of keylocked switches on panel C-904.

The valve control switches are wired in-series with the isolation logic reset so that the valve control switches must be in the CLOSED position before the logic is reset. This prevents inadvertant opening of the valves when the logic is reset.

The valve control switches (General Electric Co. type SBM) and isolation signal override switches (General Electric Co. type CR2940) were purchased as Class IE items qualified for operation in the Main Control Room. The logic relays (Agastat model EGP, Agastat model 7024, and Electrositch series 24 lock-out relays) are all located on main control panel C-904.

Cables to all containment isolation valves except two are routed in the same conduit system. No other circuit is routed through these conduits. Any failure of the conduit system due to high energy pipe break or fire will not prevent closure of the isolation valves. Any open or short circuit in the cables will result in valve closure. A "hot short" between cables (which is extremely unlikely) will not prevent valve closure, since all sources of power in the conduit system, capable of energizing the solenoids, can be deenergized by moving all valve control switches to close.

The cables to the remaining two isolation valves are routed with other control circuits. The conduit for these valves is routed through the reactor building (at elevation 23' East, elevation 51' East to North, and elevation 74' North) in area's not subject to high energy pipe breaks. Any failure of this conduit system due to other causes (fire) resulting in cable opens or short circuits will cause the valves to close. "Hot shorts" between a 120VAC or 125VDC circuit and both valve control cables (extremely unlikely) could result in two series valves opening. Opening of these valves will extend primary containment into the Category I H<sub>2</sub>/O<sub>2</sub> piping system which is designed to withstand the effects of a design basis LOCA within the primary containment.

In general, the power supplies, isolation signals, and override functions are arranged to provide the capability of isolation on a LOCA and the reopening of at least one set of sample lines after a LOCA assuming a single failure. Isolation of the sample lines is assured, in that the series valves receive isolation signals from redundant logics, the valves fail closed on loss of power, and a single failure (high voltage) of either an AC or DC supply will only prevent one valve (inboard's are DC, outboard's are AC) from closing. Reopening of at least one redundant group of isolation valves is possible assuming a single failure because of the complete independence of power supplies to the redundant subsystems and the availability of individual override switches for each group of isolation valves. A Struthers Dunn relay model No. 219CX104 provides isolation between Div. I power and Div. II logics and between Div. II power and Div. I logics.

The Class IE heat tracing system has been designed, fabricated, and delivered by Thermon Manufacturing Company in accordance with the requirements of Boston Edison Co. Specification E-509. The heat tracing system is divided into redundant subsystems; one serving Division I sample lines and one serving Division II lines. Each subsystem has a control panel (C-176/C-177) located in the electrical equipment room, with a 120/240 volt, 28 circuit distribution panelboard. Each heat trace circuit is supplied via an individual 120 volt breaker. In addition to the power distribution function, the heat trace control panels have temperature control units, high and low temperature alarm units, and current monitoring units for each heat trace circuit. 100 ohm platinum RTD's monitor the pipe temperature for input to the temperature control units which supply power to the heat trace circuit as required. The power supply (120/240 VAC) to the Division I heat trace subsystem is from Class IE panelboard Y13 breaker 10 (Div. I). The power to the Division II subsystem is from Class IE panelboard Y14 breaker 10 (Div. II). This heat trace system is also used to heat the PASS system atmosphere samples lines. The total connected load is approximately 10 kva per subsystem.

All electrical equipment has voltage and current ratings exceeding the anticipated operating conditions. Instrumentation, control, and power cables are routed in different raceways as required by "Design Criteria for Electrical Installation."

All safety related components and associated cable/conduit are installed in Seismic Category I buildings. All safety related equipment and Class IE conduit is installed to meet the requirements Seismic Category I installations.