FOR INFORMATION ONLY

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Attachment (1)

SYSTEM DESCRIPTION

COMBUSTIBLE GAS CONTROL SYSTEM

FOR THE

MONTICELLO NUCLEAR GENERATING PLANT

Prepared for:

NORTHERN STATES POWER COMPANY

Prepared by:

NUTECH ENGINEERS
San Jose, California

Approved by:

Gregg A. Reimers

G. A. Reimers
Project Engineer

Issued by:

D E Naaf

D. E. Naaf, P.E.
Project Manager

G. E. Setka

G. E. Setka, P.E.
Engineering Manager

Date: 3-4-82

nutech

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1.0 INTRODUCTION

The safety function of the Combustible Gas Control System (CGCS) is to limit the concentrations of combustible gases within the primary containment that may result from a Loss of Coolant Accident (LOCA). The CGCS is a Class 1E, Seismic Category 1, Safety Related System.

The combustible gases of concern are hydrogen and oxygen. During normal plant operation, combustion of the containment atmosphere is not a concern because the hydrogen concentration is negligible and the oxygen concentration is less than 4.4 volume percent. Following a LOCA, a fuel cladding metal water reaction, coolant radiolysis, and corrosion would result in hydrogen and oxygen generation.

2.0 OBJECTIVE

The purpose of this document is to develop an understanding of the design bases and the method by which the CGCS satisfies them. This will be accomplished by identifying the major design bases and providing a description of the system configuration, identification of major components, and a summary of functional capabilities.

3.0 SYSTEM DESCRIPTION

3.1 The CGCS shall limit the primary containment hydrogen concentration to less than 4.0 volume percent or the oxygen concentration to less than 5.0 volume percent, without releasing radioactive materials to the environment, following a LOCA. The maximum hydrogen production from the fuel cladding is the result of a 5 percent metal water reaction. This will result in an initial hydrogen buildup of 13.7 volume percent, if all the hydrogen is assumed to stay in the drywell. The CGCS shall be capable

of operating before the oxygen concentration reaches 4.5 volume percent, thereby giving 0.5 percent margin.

Each CGCS line that penetrates the primary containment shall be equipped with containment isolation valves. These valves shall automatically close on a Group II isolation signal. Post LOCA operation of the CGCS may provide an operating bypass to the containment isolation signal. The CGCS containment isolation valve control shall be limited to the main control room.

With the exception of the containment isolation function, the initiation and control of the CGCS may be by manual means. Manual control is satisfactory because immediate operation is not required since the oxygen concentration cannot reach the safety limit sooner than 14 hours post LOCA.

The CGCS safety function reliability shall be assured by providing two independent 100 percent capacity subsystems.

3.2 System Configuration

The mechanism utilized to provide the combustible gas control is a thermal recombiner located outside the primary containment. Drywell penetration X-47 provides a common suction point for both Division I and Division II (see Figure 3-1). In order to maintain divisional independence, penetration X-47 is equipped with dual isolation valves for each division.

The containment atmosphere supplied via X-47 is piped directly to the Division I recombiner located in Fire Zone 4A and similarly to the Division II recombiner located in Fire Zone 4B. The cooling water required for

each recombiner is supplied from the associated RHR division via a booster pump and strainer.

The effluent of each recombiner is returned directly to the suppression pool air space. The Division I effluent line is equipped with dual containment isolation valves and branches from the CP4-20"-HE ventilation line. Similarly, Division II branches from the CP5-18"-HE vent line.

In order to ensure that the CGCS safety function and the containment isolation safety function both retain functional capability subsequent to a single failure, the CGCS isolation logic is as illustrated in Figure 3-2.

4.0 MAJOR COMPONENT DESCRIPTION

4.1 Containment Isolation Valves A0-7422A(B)-A0-7425A(B)

Both the influent (4-inch) and effluent (6-inch) isolation valves are air actuated and fail closed on loss of air or power to the pilot solenoids. Each valve has position indication, via limit switches, on panel C03 in the control room and on CGCS logic panel C285A(B). Valve control is limited to panel C03.

4.2 Recombiner Unit - C288A(B)

The recombiners are forced circulation thermal types. A regenerative type centrifugal blower (20 HP) is used to circulate the process gas. The gas is processed in three steps which include heating, hydrogen recombination, and cooling of exhausted gas. Each recombiner is equipped with three motor-operated valves, MO-4043A(B), MO-4044A(B), and MO-4047A(B). Valve MO-4043A(B) is used to regulate the process gas incoming flowrate, while valve MO-4044A(B) is used to regulate the dilution flowrate to the reaction

chamber. The capacity of the reaction chamber for flows ranging from 140-160 SCFM is limited to:

% H_2 by volume	% O_2 by volume
0.5 - 5.0	0.25 - 2.5

The process gas inlet flowrate range is 60-160 SCFM. Dilution flow is utilized to maintain the reactants within the range of the reaction chamber. Dilution is provided by diverting and mixing a portion of the recombiner exhaust, which will be either hydrogen or oxygen deficient, with the incoming process gas.

Heating of the process gas is accomplished in a spiral pipe coil heat exchanger. The exterior walls of the heating coil are exposed to radiant heat from electrical resistance heaters (108KW).

The hydrogen/oxygen recombination takes place in a reaction chamber, at a temperature of 1325°F, which is located downstream of the heater. Immediately after leaving the reaction chamber, the gas is cooled as it flows through a water contact spray cooler. The cooling water is controlled by valve MO-4047A(B).

4.3 Cooling Water Booster Pump - CGC-P1A(B)

The recombiner unit requires 10-15 gpm at 85-150 psig in order to sufficiently cool the recombiner exhaust. The RHR System is capable of supplying 50-250 psig water at the CGCS interface. When the RHR System pressure drops below 150 psig, the booster pump shall provide an additional developed nominal head of 100 psig.

4.4 Pressure Regulator - PCV-4037A(B)

As described in Section 4.3 above, the RHR System pressure can also exceed the cooling water pressure requirements of the recombiner unit. The pressure control valve is a self-contained pressure regulator set at 120 psig nominal and provides cooling water at a constant pressure.

4.5 Strainer - BS-4033A(B)

The contact spray cooler on the recombiner unit is designed for a maximum particulate size of 100 microns. The RHR water is pre-screened to limit particle sizes to 1/8 inch by the ECCS suction strainers. The CGCS strainers are motorized, self-cleaning strainers. The strainer backflush, which is limited to 25 gpm, is discharged into the recombiner effluent line. The effluent line is sloped towards the suppression pool, thereby providing a continuous drain path.

4.6 CGCS Power Cabinets - C287A(B)

The power cabinet contains the equipment related to the power supply required for operation of the recombiner unit and recombiner control panel. Contained within the power cabinet are the heater SCR controller, blower and valve motor starters, and the power supply for the recombiner control panel. The power cabinet is de-energized whenever the recombiner is not functioning.

4.7 Recombiner Control Panel - C286A(B)

The recombiner control panel contains all the necessary instrumentation and controls for the remote manual operation of the recombiner. This cabinet contains flow indicators, temperature indicating controller, inlet and dilution valve control switches, annunciators, multi-point digital thermocouple readout device, and other

support instrumentation and controls.

4.8 CGCS Logic Panel - C285A(B)

The logic panel contains all the logic required for interfacing the recombiner control panel (C285A&B) with the remainder of the plant, containment isolation valve logic, and the booster pump (CGC-P1A&B), and strainer (BS-4033A&B) control logic. Additionally, this panel provides containment isolation valve position indication.

5.0 INSTRUMENTATION AND CONTROL DESCRIPTION

5.1 Control Room

The CGCS indication available to the control room operator consists of:

- System status indicating lights
  - GREEN = Off
  - RED = Operating
  - AMBER = Recombiner trip
- Containment isolation valve position indication for each valve
  - GREEN = Closed
  - RED = Open

The CGCS controls available to the control room operator consist of the containment isolation valve control switches. There are two switches per division one for both the influent and effluent inboard valves (CS1A&B), and similarly one switch for both outboard valves (CS2A&B). Besides normal opening and closing of the associated valves, these switches initiate the Group II isolation signal operating bypass. Additionally, only if

both switches within a division are simultaneously in the OPEN position, does the recombiner power cabinet (C287A&B) become energized. Placing either, or both, of the control switches in the CLOSE position will close the associated isolation valves, shutdown the recombiner, and after a 30-second time delay, de-energize the power cabinet. The containment isolation bypass signal will be automatically reset upon isolation valve closure, recombiner trip, or resetting the Group II isolation signal.

The CGCS control room annunciators consist of a CGCS trouble alarm and CGCS automatic isolation bypass alarm for each division.

5.2 CGCS Logic Panel - C285A(B)

The CGCS logic panel provides the following status indication:

- Containment isolation valves AO-7422A&B, AO-7423A&B, AO-7424A&B, and AO-7425A&B position lights.
  - GREEN = Closed
  - RED = Open
- Cooling water booster pump CGC-P1A&B status lights.
  - GREEN = Off
  - RED = On
- Cooling water booster pump suction valve SV-4033A&B and discharge valve SV-4032A&B position lights.
  - GREEN = Closed
  - RED = Open

- Strainer, BS-4031A&B, cleaning mechanism status lights.
  GREEN = Off
  RED = On
- Cooling water booster pump bypass valve SV-4034A&B position lights.
  GREEN = Closed
  RED = Open

The only control feature provided on this panel is the cooling water purge control switch (CS3A&B). When in the NORMAL position, cooling water flow is initiated whenever the recombiner is operating. When the switch is in the PURGE position, the cooling water flow is terminated and the recombiner heater is de-energized.

5.3 Recombiner Control Cabinet - C286A&B

The recombiner control cabinet provides the following status indication:

- Recombiner trickle heater.
  RED = On
- Power cabinet (C287A&B) and control cabinet energized.
  WHITE = Power on all circuit breakers
- Recombiner status.
  RED = Standby ready
  RED = Startup
  RED = Operate
- Inlet valve MO-4043A&B, dilution valve MO-4044A&B, and cooling water valve MO-4047A&B position lights.
  GREEN = Closed
  RED = Open

The following process indication is also available on the recombiner control cabinet.

- Process gas inlet flow from containment, FI-4041A&B
- Reaction chamber process gas flow, FI-4052A&B
- Reaction chamber temperature and heater controller, TIC-4046A
- Process gas inlet temperature, TI-4035A&B
- Blower inlet temperature, TI-4053A&B
- Heater process gas temperature 2/3 through heater, TI-4050A&B
- Heater outlet process gas temperature, TI-4048A&B
- Heater wall temperature, TI-4049A&B
- Reaction chamber shell temperature, TI-4045A&B
- Exhaust gas temperature, TI-4042A&B
- Inlet process gas pressure, PI-4051A&B

The control features available on the recombiner control cabinet include an OPERATE/OFF control switch (HS-3A&B), a process gas inlet valve control switch (HS-4043A&B), and a dilution valve control switch (HS-4044A&B). The OPERATE/OFF control switch is interlocked with the effluent inboard and outboard containment isolation valve open limit switches and the ECCS load shed logic. The inlet valve control switch and the dilution valve control switch are used to throttle the associated valves, thereby maintaining the hydrogen and oxygen concentrations within the reaction chamber limits.

The following conditions are alarmed by the recombiner control cabinet annunciators.

- Process gas inlet temperature high. TS_H-4035A&B
- Blower inlet temperature high, TS_H-4053A&B. Initiates CGCS trip.
- Heater process gas temperature 2/3 through heater high, TS_H-4050A&B. Initiates heater trip.
- Heater outlet gas temperature high, TS_H-4048A&B. Initiates heater trip.
- Heater wall temperature high, TS_H-4049A&B. Initiates CGCS trip.
- Reaction chamber shell temperature high, TS_H-4045A&B. Initiates CGCS trip.
- Exhaust gas temperature high, TS_H-4042A&B. Initiates CGCS trip.
- Inlet process gas pressure high, PS_H-4051A&B. Initiates CGCS trip.
- Reaction chamber process flow low, FS_L-4052A&B. This alarm has a 60-second time delay interlock upon recombiner startup. Initiates heater trip.
- Reaction chamber temperature low, TS_L-4046A&B. This alarm has a 240-minute time delay interlock upon recombiner startup.
- Cooling water pressure high, PS_H-4040A&B.
- Cooling water pressure low, PS_L-4040A&B. This alarm is interlocked with the cooling water purge control switch (CS3A&B) and a 50-second timer to allow for recombiner startup.

6.0 SYSTEM OPERATIONAL SUMMARY

Prior to initiating CGCS, verify that

- At least one RHR pump is running (assuming RHR cross-tie is open).
- ECCS load shed logic is reset.
- Drywell pressure is less than 15 psig.
- Dyrwell temperature is less than 203^{O}F.

To open the containment isolation valves, first place both control switches CS1A&B and CS2A&B in the OPEN position. Verify that the CGCS amber trip light is extinguished. Momentarily place CS1A&B in the CLOSED position. This will initiate the inboard isolation bypass and associated alarm. Returning CS1A&B to the OPEN position (within 30 seconds) will open both inboard valves. Similarly, momentarily place CS2A&B in the CLOSED position. Verify that all of the CGCS containment isolation valves are open.

To actuate the recombiner and cooling system, verify that cooling water control switch CS3A&B is in the NORMAL position and place the recombiner control switch HS-3A&B in the OPERATE position. Actuating the recombiner operate circuit starts the blower. As the blower starts, cooling water valves MO-4047A&B and either SV-4034A&B or SV-4035A&B plus SV-4032A&B open, depending upon the current RHR line pressure and the need for the CGCS booster pump. If SV-4035A&B and SV-4032A&B both open, the booster pump will automatically start. Additionally, opening the recombiner cooling water inlet valve (MO-4047A&B) starts the cleaning mechanism on strainer BS-4031A&B. The process gas inlet valve (MO04033A&B) should then be opened via control switch HS-4043A&B until the desired flowrate is achieved.

When flow is established and the water inlet valve is full open, the heater power comes on. As the temperature of the heater section increases, the gas being circulated through the recombiner is heated. The hydrogen in the gas permits the hydrogen-oxygen reaction to occur when the heater outlet gas temperature is approximately 1150°F (621°C). The reaction first occurs at the heater section. When the gas temperature exceeds 1300°F (704°C), an interlock turns off the power to the heaters. The heater section starts to cool, except near the exit where the reaction is taking place. The hot reaction gases are carried into the reaction chamber. Within about 30 minutes, depending on the amount of hydrogen in the gas, the heater cools to the point where it can no longer sustain the reaction, and the reaction moves into the reaction chamber.

The heater gas now reads less than 1300°F (704°C) and the interlock is cleared. With the reaction occurring in the reaction chamber, a constant reaction chamber gas temperature is maintained by the temperature controller on control panel. The heater section temperatures are below those required for reaction, so the reaction stays in the reaction chamber.

When the temperature of the reaction chamber gas is greater than 1140°F (621°C), the recombiner is in the OPERATE mode. The temperature controller maintains a stable temperature of 1325°F (718°C) at the reaction chamber.

In the OPERATE mode, the recombiner will run with minimum attention. During startup and approximately once per shift, it will be necessary to log the properties of the containment gases to determine whether a flow adjustment should be made.

If any of the essential recombiner operating parameters exceed operational limits, the CGCS will automatically trip and, if a Group II isolation signal is present, the CGCS containment isolation valves will automatically close.

During recombiner shutdown, the process gas piping can be purged by leaving the recombiner in the OPERATE mode and placing CS3A&B in the PURGE position. This will keep the blower on, terminate cooling water, and shutdown the heater.

7.0 RELATIONSHIP TO OTHER SYSTEMS

7.1 Residual Heat Removal - RHR

The RHR System must be functioning such that the pressure at the operating pump(s) discharge is within its normal operating range of 130-330 psig. Additionally, the RHR process temperature must be less than 150°F. This may require the containment cooling heat exchanger to be valved in. RHR operation is not required during CGCS purging.

7.2 Containment Atmosphere Monitoring - CAM

The CAM System must be utilized to determine the hydrogen and oxygen concentration levels within the containment. Additional sample points will also be provided on the recombiner inlet and exhaust lines.

7.3 Safety Related Air Supply - (later)

The CGCS containment isolation valves are air operated. The source of air has not yet been established.

7.4 Auxiliary Power System

The CGCS is supplied by an essential bus. To eliminate any diesel generator loading concerns during the post LOCA short term, the recombiner is load shed as part of the ECCS load shed scheme. Analysis has indicated that CGCS operation during that period is not required.

7.5 Containment Mixing - (later)

If forced mixing is determined to be necessary, it will be addressed separately and become an auxiliary support feature for CGCS.

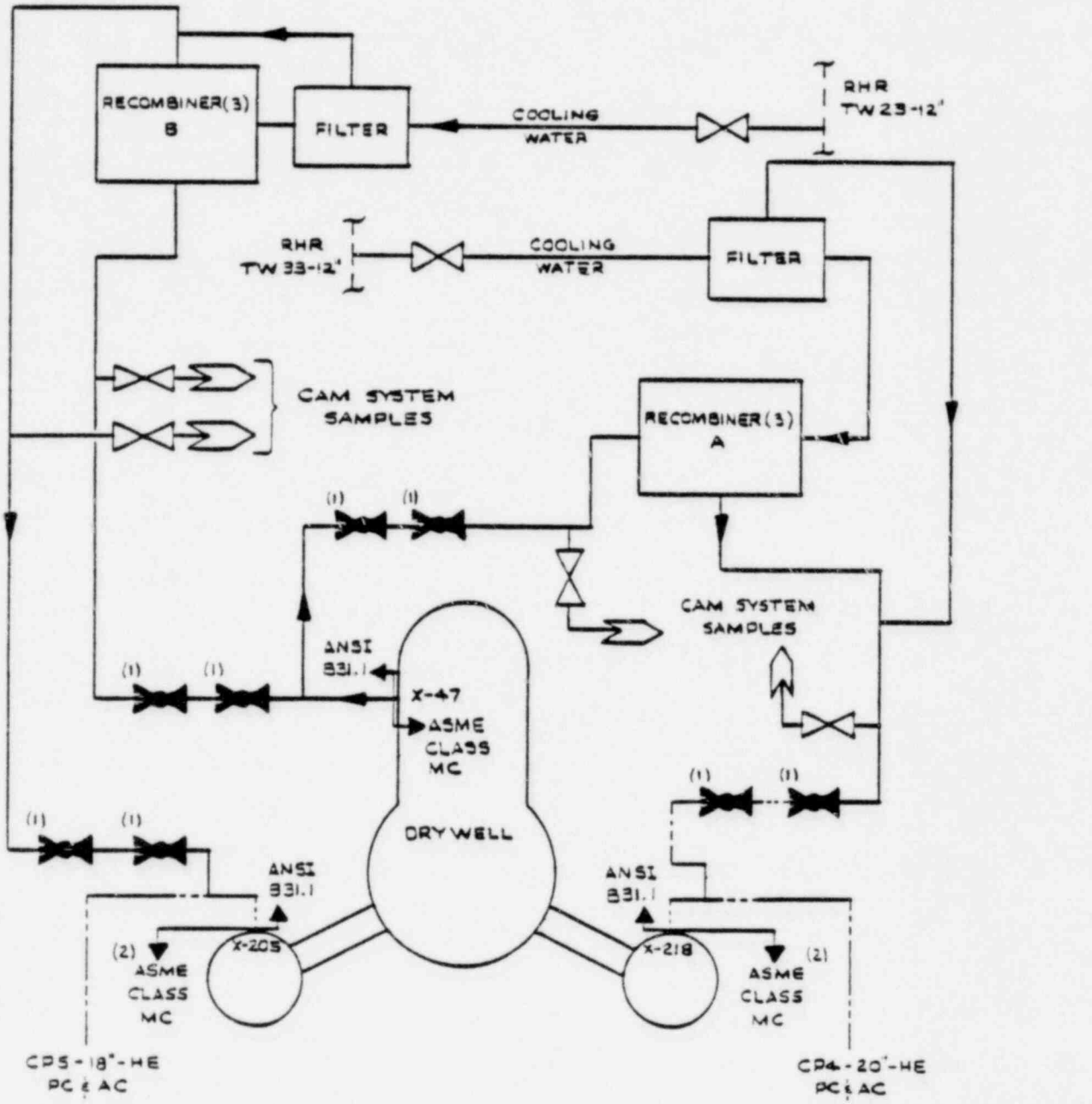
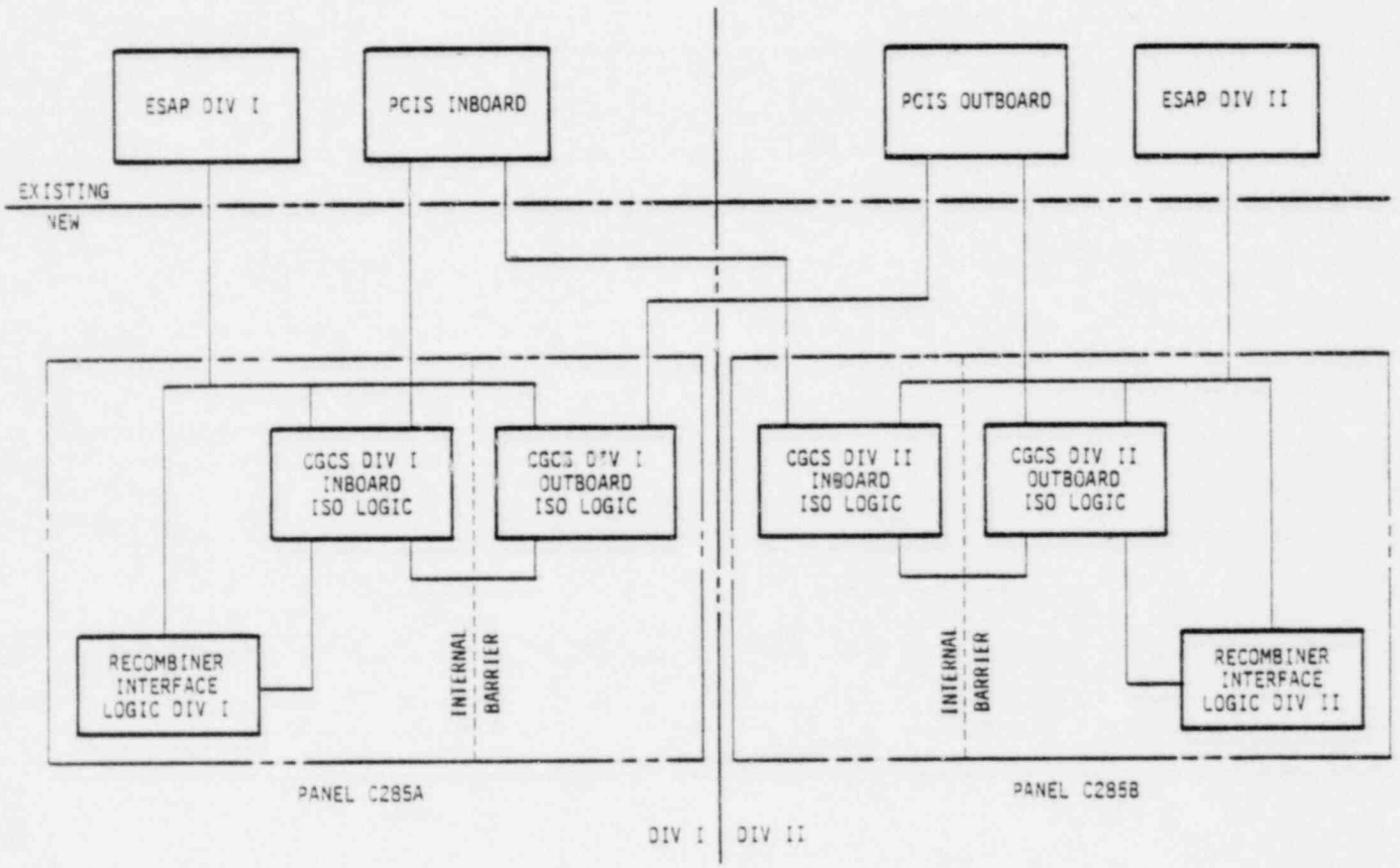


FIGURE 3-1

COMBUSTIBLE GAS CONTROL SYSTEM

SIMPLIFIED FLOW DIAGRAM

FIGURE 3-2
CGC SYSTEM LOGIC PANEL
SEPARATION REQUIREMENTS



ESAP = ESSENTIAL SERVICE AUXILARY POWER
PCIS = PRIMARY CONTAINMENT ISOLATION SYSTEM

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