

SINGLE-FAILURE ANALYSIS FOR THE NEUTRON MONITORING
AND PROCESS RADIATION MONITORING SYSTEMS

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Some of the safety-related portions of the neutron monitoring system (NMS) and the process radiation monitoring system (PRMS) for the Hope Creek Generating Station (HCGS) are not designed and built to conform to the literal separation guidelines of Regulatory Guide 1.75. This analysis establishes the acceptability of these portions of the NMS and PRMS by demonstrating that they meet the single-failure criteria of IEEE Standard 279, which requires that the consequences of any single, design-basis failure event in a safety-related portion of the systems be tolerated without the loss of any safety function.

Portions of NMS and PRMS External to the NMS and PRMS Panels

See Figure 7.1-1 of the HCGS FSAR for the separations concept of the reactor protection system (RPS) and its relationship to the NMS.

Under the reactor vessel, cables from the individual, local power-range monitor (LPRM) detectors and from the individual intermediate-range monitor (IRM) detectors are grouped to correspond with the RPS trip channel designations. These cable groupings are run in conduit from the vessel pedestal area to the NMS and PRMS panels.

The radiation monitors on the main-steam lines are physically separated. The cabling from the individual sensors to the panels is run in separate metallic conduit.

Cabling from the NMS and PRMS panels to the RPS cabinets is also run in metallic conduit, providing electrical isolation and physical separation of the NMS and PRMS cabling associated with the RPS system.

It is concluded that the safety-related portions of the NMS and PRMS external to the NMS and PRMS panels adequately conform to the separation criteria of Regulatory Guide 1.75.

Single Failure in the NMS and PRMS Panels

Figures 1 and 2 depict schematically the physical arrangement of the equipment in NMS and PRMS panels H11-P608, H11-P635, and H11-P636. The designs of these panels are similar to those of NMS and PRMS panels used in several BWR plants accepted by the NRC.

The layouts of the panels and the assignments of specific RPS trip logic circuitry provides the designs with the required tolerance to postulated single failures. The worst-case single failure would be the loss of any combination of trip signals within one bay of any panel. However, the loss of any bay and its associated wiring would not prevent a scram. A valid scram signal would be transmitted via the other bays because of the redundancy in the panel designs and the interconnections to the RPS (see Figure 7.1-1 of the HCGS FSAR).

The eight IRM channels and the six average power range monitor (APRM) channels are electrically isolated and physically separated. Within the IRM and APRM modules, analog outputs are derived for use with control room meters, recorders, and the process computer. Electrical isolation at the interfaces would prevent any single failure from influencing the trip unit output.

Physical Separation in the NMS and PRMS Panels

Adequate separation in the NMS and PRMS panels is achieved by using the bay design depicted in Figures 1 and 2, by using relay coil-to-contact as sufficient separation/isolation, and by separation between divisions/channels/wiring. Where conformation with Regulatory Guide 1.75 separation criteria cannot be achieved, the best-effort design is used.

Circuits that provide inputs to different divisions of the RPS are physically separated by airgaps or by the walls between the bays. Within the panels, where the cable and wiring runs to the different RPS divisions do not conform to the Regulatory Guide 1.75 separation criteria, fire-resistant "Sil-Temp" tape is wrapped around the cables and wires. This eliminates the possibility of fault propagation between the RPS divisions. In accordance with paragraph 5.6.2 of IEEE Standard 384, this tape has been demonstrated to be acceptable.

Non-RPS interfacing cables or wires not conforming to the separation criteria of Regulatory Guide 1.75 were not wrapped in SIL-Temperature tape.

Separated ducts are provided in the panel for the incoming circuit wires from the sensors that belong to UPS Bus 1 or Bus 2.

As shown in Figure 3, the isolation/separation precludes the propagation from outside the NMS cabinets of failures that could cause the loss of any safety function.

NMS/PRMS Interface to RPS

Although the LPRM sensors are not required to meet Class 1E requirements, the design bases of the APRMs specify that the LPRM signals used for the APRMs be so selected, powered, and routed that the APRMs do meet applicable safety criteria. The LPRM signal conditioners and associated power supplies are isolated and separated into groups.

The logic circuitry for the NMS and PRMS scram trip signals conforms to the single-failure criteria. The contact configurations and failure consequences associated with IRM A (see Figure 4) and APRM A (see Figure 5) are typical of the other trip channels and are described in what follows.

- With the reactor scram mode switch in the "Shutdown," "Refuel," or "Startup" positions, IRM A upscale or inoperating signals (unless bypassed) or APRM A upscale or inoperative signals (unless bypassed) would produce a channel trip of the output relay.
- With the reactor system mode switch in the "Run" position, IRM A upscale or inoperative signals (unless bypassed) and an APRM A downscale signal (unless bypassed) or APRM A upscale neutron trip or upscale thermal trip or inoperative signals (unless bypassed) would produce a channel trip of the output relay.
- A trip of the channel output relay for IRM A and APRM A or a trip of the channel output relay for IRM E and APRM E would produce an RPS A1 channel trip. In PRMS, the log radiation monitor A would produce an RPS A1 channel trip (see Figure 6).

For NMS, one tripped (unbypassed) channel on the RPS trip system would cause a half scram. If one APRM bay were to fail in an untripped condition, the remaining bays would be capable of sending RPS sufficient scram signals to produce a full scram, even if one of them were bypassed.

As shown in Figures 2 and 7, if one bay of panels H11-P635 or H11-P636 were to fail in an untripped condition, the remaining bays would be capable of sending sufficient RPS signals even if one of the IRM channels were bypassed. The IRM bypass switches can bypass one IRM channel at a time.

Similarly for PRMS, if one bay were to fail in an untripped condition, the remaining bays would be capable of sending sufficient RPS trip signals to produce a full scram.

Common Power Supply Justification

The NMS is supplied with 120-Vac, 60-Hz power from UPS busses 1 & 2. A design change has been authorized for the installation on each bus of redundant electrical protection assemblies (EPAs), which will monitor the incoming voltage and frequency.

Any fault in one NMS channel could not cause an unsafe failure in another channel sharing the same low voltage power supply because 10-amp fuses are installed for wire protection, and the power supplies are designed with over-voltage and over-current protection circuitry at their output.

The PRMS is supplied with 120-Vac, 60-Hz power from RPS busses A and B. EPAs are already installed on each bus to provide voltage and frequency protection.

Any fault in one PRMS channel could not cause an unsafe failure in another channel sharing the same power supply because 5-amp fuses are installed for wire protection, and the power supplies are designed with over-voltage and over-current protection circuitry at their output.

Because of the fail-safe NMS/PRMS logic configuration, a loss of one supply would result in a half scram signal to RPS. Loss of both supplies would result in a full scram.

Common Associated Circuit Interfaces

Nonessential (associated) circuits to common information equipment are current limited and protected such that their failure cannot jeopardize an adjacent circuit.

Figure 8 provides an example of an associated circuit interface on LPRM card Z11. At the zero-to-160-mV computer output, the card is protected with a 30-MA fuse. The zero-to-10-V output to the rod block monitor has an additional isolator protection for the card.

PANEL
H11-P608

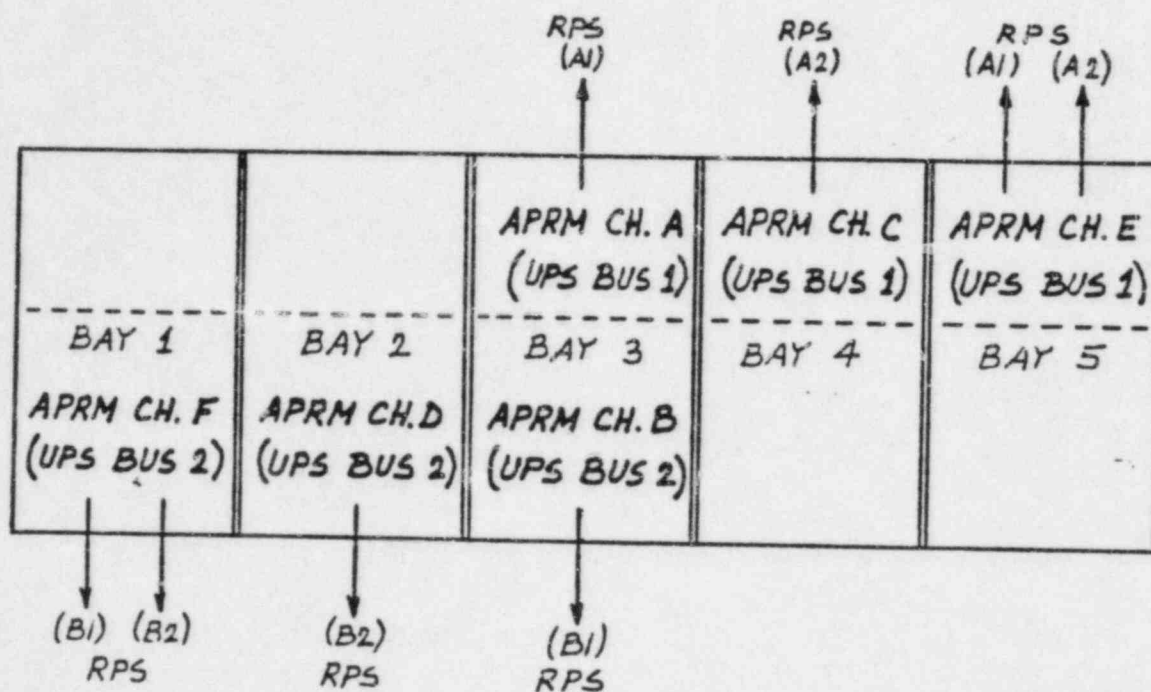
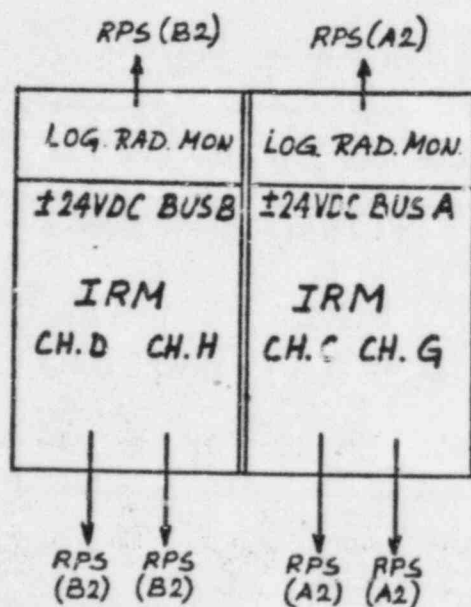


FIGURE 1 - APRM Panel Assignment

PANEL
H11-P635



PANEL
H11-P636

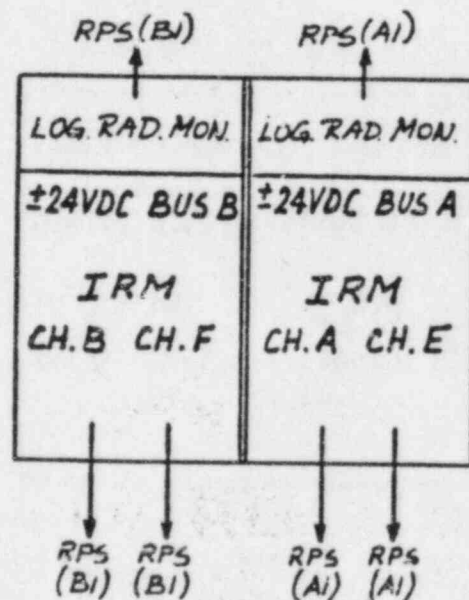


FIGURE 2 - Radiation Monitoring Panels

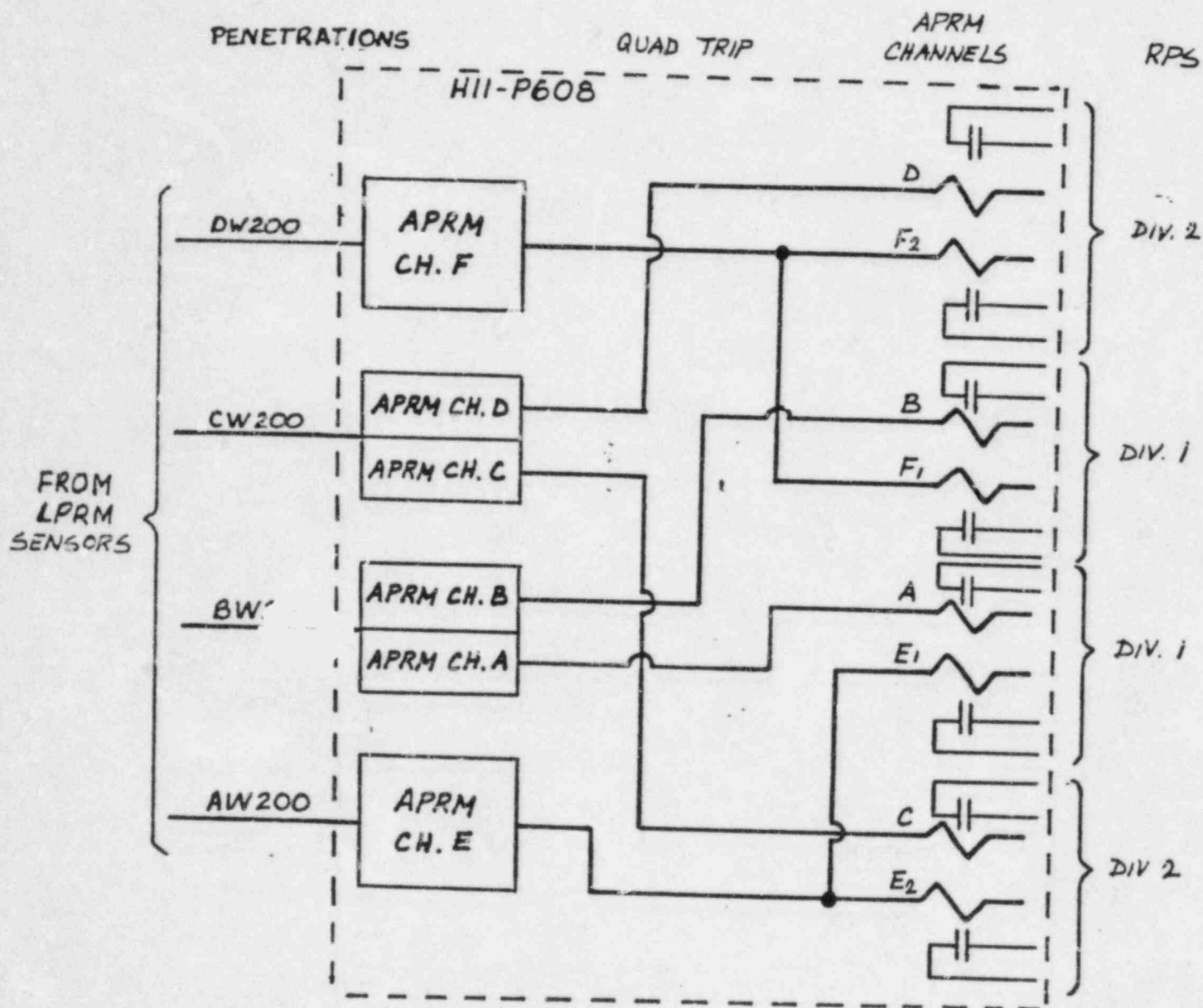


FIGURE 3 - APRM/RPS Signal Separation

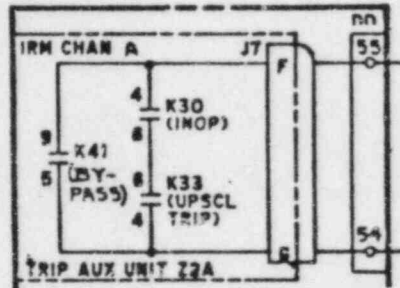


FIGURE 4 - IRM Channel A

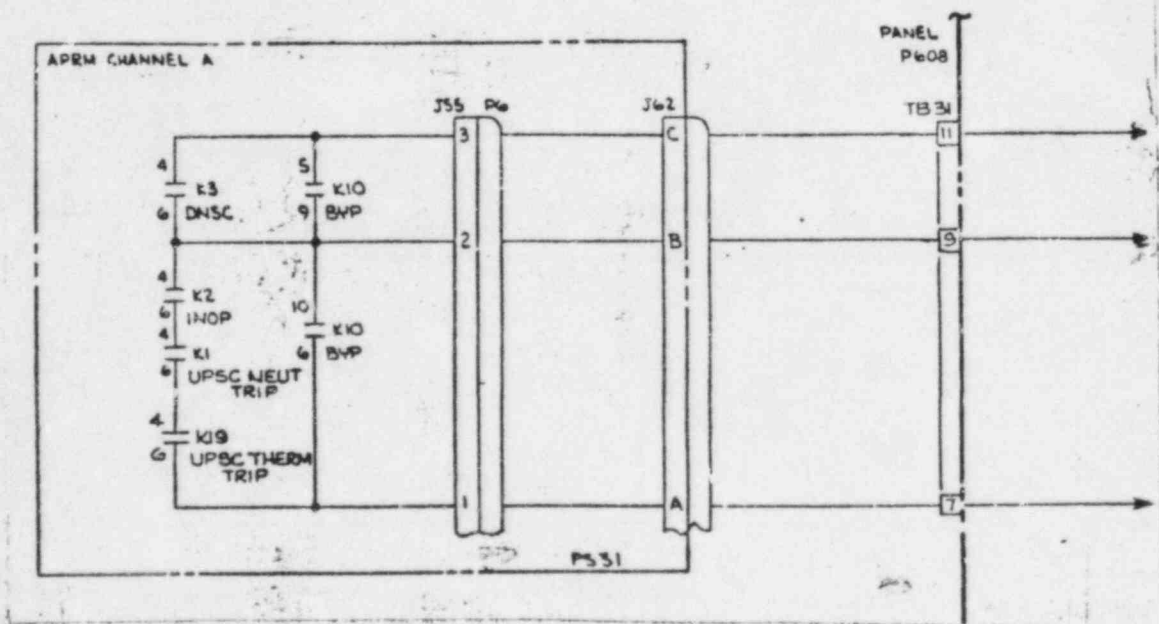


FIGURE 5 - APRM Channel A

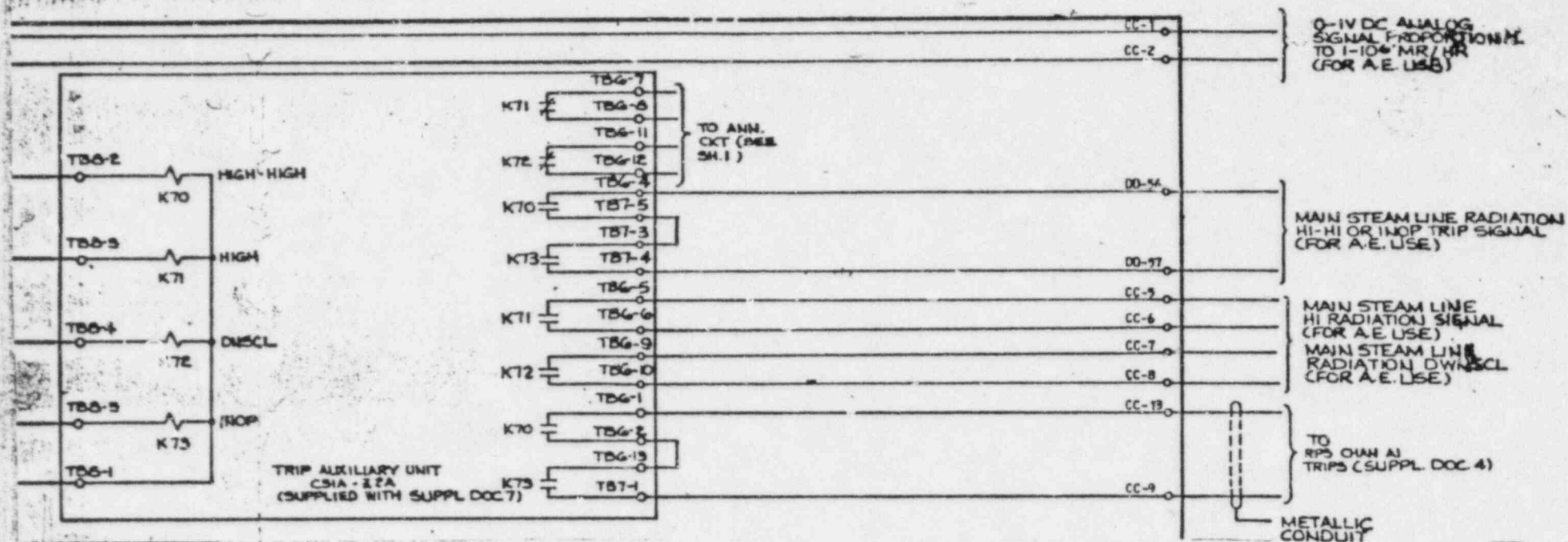


FIGURE 6 - Log Radiation Monitor Channel A

