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REPORT
ON
PSE&G
CABLE
SEPARATION
STUDY

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REVIEW OF PSE&G CABLE SEPARATION STUDY

As part of the overall fire protection review, the staff reviews the cable separation study performed by the licensee to confirm that there is reasonable assurance that a single fire would not destroy the redundant components of systems necessary for shutdown.

In order to expedite the conduct of this review for the Salem Station, a team of people was sent to the plant. The team consisted of:

- 1) Janis Kerrigan, team leader
- 2) Gary Meyer, Project Manager for Unit 2
- 3) Lief Norrholm, Senior Resident Inspector
- 4) Ralph Pallino, Regional Inspector
- 5) John Knox, NRC staff electrical expert
- 6) Jim Behm, fire protection consultant
- 7) Bernie Mann, NRC staff systems expert

The objectives of the team were to:

- 1) make a finding on the adequacy of the cable separation study and the program used to implement the results of that study, and
- 2) make a finding on the adequacy of the corrective actions implemented as a result of the cable interaction program. These findings should concentrate on the adequacy of the fire protection measures on an interim basis. The adequacy of the measures on a long term basis will be covered by the staff in its review of the licensee's compliance with App. R.

I. Evaluation of Program Implementation

In order to evaluate the adequacy of the implementation of the licensee's fire protection program, we followed a number of systematic review steps. Those steps and our conclusions are presented below.

First, we evaluated whether the systems considered and identified by the licensee in his program are adequate to bring the plant to hot shutdown, to maintain hot shutdown for either short or long time periods, and to bring the plant to cold shutdown. Based on discussions with the licensee, we conclude that there is reasonable assurance that the systems identified exceed the minimum number required to maintain hot shutdown and to bring the plant to safe cold shutdown given a design bases fire.

Second, we evaluated whether the equipment and cables associated with each system were identified and are of a sufficient number to assure system functionality. Based on a 50 percent audit, piping and instrument drawings and discussions with the applicant, we conclude that there is reasonable assurance that equipment and cables have been identified that exceed the minimum number required to assure system functionality.

Third, we evaluated whether the licensee adequately identified the routing of cables throughout the plant. Based on a 50 percent audit, discussions with the licensee, computer printouts of cable routing schedules, physical

equipment and raceway layout drawings, and actual cable raceway tracing during plant walkthroughs, we conclude that there is reasonable assurance that cable routing was adequately identified.

Fourth, we evaluated whether the licensee's program identified the specific equipment and cables requiring protection from a design basis fire. Based on a 50 percent audit, discussions with the applicant, and plant walk throughs, we conclude that there is reasonable assurance that equipment and cables requiring additional protection were identified.

The final step of the licensee's program (overall program verification) has not yet, been completed. OIE will monitor the licensee's progress in this area.

The team therefore concludes that the cable separation program for the Salem Station is acceptable.

II. Adequacy of Corrective Actions

In order to accomplish our second objective, which was to evaluate the adequacy of the corrective actions taken, the team performed an extensive field audit. Based on that audit, the team found that for many areas of the plant the fire protection measures implemented at the Station met or exceeded NRC requirements. However, we did find that some additional fire protection measures would be required in some areas.

In reaching our findings, we were able to trace the particular fire protection measures implemented back to the basic assumptions and criteria used by the licensee. (See Table 1). We then divided these criteria into 5 basic categories:

- 1) Criteria that had no impact on our review and therefore the acceptability of these criteria was not addressed by the team. (Criteria 2,9,12).
- 2) Criteria which the team agrees with and which the team found no examples of the criteria not being met. (Criteria 3, 6, 7, 8A, 11, 13, 14c).
- 3) Criteria which the team agrees with and which the team found examples of the criteria not being met (Criterion 1). The team understands that the final program verification is not complete, and we realize that at least some of the examples would have been picked up. For items in this category, the team found that additional fire protection measures would be necessary.
- 4) Criteria with which the team did not agree. The team concluded that the fire protection measures implemented using the criteria in this category were not adequate and that additional fire protection measures would be necessary. (Criteria 4, 8b, 14a, 14b).

- 5) One criterion (10) which dealt with areas of the plant which require alternate shutdown capability.

A. Category 1 Criteria

In regard to Criterion 2, "The intensity of the postulated fire decreases with height provided that no combustibles are present within the zone of influence," Criterion 9, "Cable-initiated fires are not credible," and Criterion 12, "An exposure fire inside containment is not credible," we conclude that these criteria had no impact on this evaluation. Thus their acceptability will not be addressed in this report.

B. Category 2 Criteria

In regard to Criterion 3, "If horizontal filled cable trays are present within and/or above the 20 foot diameter zone of influence of the fire, the zone of influence is extended out, in a cone shape configuration to include these combustibles," Criterion 6, "Cable will burn, but does not support combustion. Therefore, there is assumed to be no further propagation of fire along a horizontal cable tray once the fire source is removed," Criterion 7, "Conduit, although not considered to be combustible, was also not considered to provide a fire barrier to its enclosed cables," Criterion 8A, "The primary fire suppression system in an affected area is assumed to fail," Criterion 11, "Manual fire-fighting techniques only are required for the control room since the control room is constantly manned," Criterion 13, "All auxiliary feedwater trains will be protected that are within the 20 foot zone of influence of the fire," Criterion 14.c, "A 1 1/2 hour barrier on ventilation ducts that go through a three hour barrier separating redundant system is an adequate protective measure", we agree with the criteria, found no examples of non-compliance with these criteria during our review and thus, conclude

that there is reasonable assurance that the licensee has met these criteria.

C. Category 3 Criteria

1. Criterion 1

In regard to Criterion 1, "The design basis fire has a 20 foot diameter zone of influence and has a zone of influence that extends from the floor to the ceiling," we agree with this criterion but as a result of our review we found several areas in which the licensee did not apply this criterion. (A list of these are areas is contained in Table 2.) Two examples of this are:

Example a: Two trains of the primary 125 DC control power to the 4160 volt, 460 volt and 230 volt switchgear are located within 20 feet of their redundant counterpart above the 4160 volt switchgear at elevation 64. The licensee indicated that the backup feed to the switchgear could be used in the event of fire, however, we found that both the primary and backup feeds are located within 20 feet so that redundant trains would be affected. The team concludes that the primary feeds to the switchgear need to be wrapped. The wrap for Unit 2 should be installed before exceeding five percent power and the wrap for Unit 1 should be installed within two weeks.

Example b: During the course of the staff's onsite review, one area in the 480/230 VAC Switchgear Room on elevation 84' in the Auxiliary Building was identified in which a single postulated 20-foot diameter fire could potentially fail all instrument channels, including the independent safe shutdown instrumentation provided for alternate shutdown. The review team concluded that this presented an immediate safety concern.

Accordingly, the Office of Inspection and Enforcement obtained, and documented in correspondence dated May 5, 1981, a licensee commitment to take immediate corrective actions. These actions included:

- a. Re-routing of the alternate shutdown power feed in order to provide protection for this cable from a fire affecting the normal instrument trains. This will be completed by June 5, 1981 for Units 1 and 2.
- b. Immediate stationing of a dedicated, continuous fire watch in the 84' elevation switchgear room until the modification described above is completed.
- c. During the period when new leads are being landed, and no power feed to the alternate shutdown instruments is available, an additional fire watch will be stationed continuously in the Relay Room.
- d. The final engineering verification of the fire protection analysis and corrective actions, which will confirm no similar mis-routings, will be completed by June 5, 1981.

The Office of Inspection and Enforcement will confirm these actions. For other examples falling under this category (see table 2), the team conclusion is that modifications should be completed in accordance with the licensee's cable wrap schedule.

D. Category 4 Criteria

In regard to Criteria 4, 8.b, 14.a, and 14.b, we do not agree with the criteria and conclude that the fire protection measures implemented using the criteria are not adequate and that additional fire protection should be required. The basis for our not agreeing and the additional protection necessary is discussed below.

1. Criterion 4

The licensee has assumed that an exposure fire, which originates on the floor, will only have a flame height of from two to four feet. Also if this fire is located against one side of the fire partition barrier the licensee has assumed that there will be no horizontal heat transmission across the top of the eight foot barrier. We disagree with the licensee's assumptions for the following reasons:

1. Transient combustibles may be stacked against the fire partition which could produce a flame front which exceeds the height of the barrier. This is especially true with flammable liquids in which a flame front of from 10 to 12 feet may be expected. Such a flame height will expose redundant safety trains above the barrier if they are within the zone of influence of the fire.
2. Heat transfer will occur across the top of the fire partition well as extending outward. Also, heat will start spreading outward from its source at the ceiling level thereby by-passing the 8 foot high barrier located on the floor. Therefore, the redundant safety system on the other side of the barrier can be exposed to the same fire.

3. A related concern about this criterion is that the length of the installed barriers do not preclude water used in fighting the fire manually from affecting redundant equipment.

During the team audit, several areas were identified in which the licensee applied criterion 4 (See in Table 2). The team concludes that corrective action for all areas in which criterion 4 was applied to components needed for shutdown should be completed in accordance with the licensee's cable wrap schedule. One example of an area in which criterion 4 was applied is discussed below. The corrective action is also discussed.

Example: In the 4160 volt switchgear room, redundant control and power cables are located above the fire barrier separating the switchgear units.

For the reasons stated above, the team concluded that the existing barriers need to be modified or extended and that the redundant cabling above the barrier needs to be protected in order to minimize the likelihood of affecting redundant equipment by either the fire itself or by water used in fighting the fire manually. These modifications should be completed on the licensee's cable wrap schedule.

2. Criterion 8b

The licensee has assumed that where redundant safety related conduit and/or cable trays are within a 20 foot zone of influence of the fire that an automatic suppression system is not necessary. We disagree with the licensee's assumptions. Within this zone of influence we expect one of the safety systems to fail as a result of the fire. We do not consider it acceptable

to leave a fire impinging on the only safety-division remaining until the plant fire brigade responds and manually extinguishes the fire. In addition during the forty year life of the plant any modifications to the cable tray may lessen its fire resistance to an unacceptable level.

The NRC fire consultant recommended that primary suppression systems be automatic versus manual. One area in which a manual suppression system is used for the protection of redundant equipment is the 460 volt switchgear room. Other areas identified by the team are included in Table 2.

We find the manual suppression system acceptable on an interim basis. For the long term fix, we understand that the licensee has requested an exemption from the Appendix R requirement that the primary suppression system be automatic. We recommend that the NRC review of the exemption request consider the NRC fire consultant's recommendation for the Salem Plant.

3. Criterion 14a

The licensee has assumed that for an exposure fire which originates on the floor, a one hour fire rated barrier or partition between redundant safety related equipment and/or conduit - cable trays is sufficient to prevent damage to the one safety train. The licensee has also assumed that an automatic primary fire suppression system is not necessary since the fire brigade will respond in sufficient time to prevent loss of redundant safety trains.

The NRC fire consultant recommended that primary automatic suppression systems be installed where redundant cables are within the influence of

the 20 foot design basis fire and protected only by a 1-hour fire barrier wrap. We find the manual hose suppression acceptable on an interim basis. For the long term we understand that the licensee has requested an exemption from the Appendix R requirement that barriers and automatic suppression be installed. We recommend that the NRC review of the exemption request consider the NRC fire consultant's recommendation for the Salem plant.

4. Criterion 14b

The licensee has assumed that for specific areas protected by an automatic suppression system, the primary fire suppression system fails. The licensee has provided a redundant automatic suppression system for these areas.

We disagree with the licensee's assumptions that the redundant suppression system will react fast enough to prevent damage to safety related equipment and/or cable tray and conduit. The thermal lag of the sprinkler heads has a heat sink of sufficient magnitude to prevent their operation prior to damage to safety systems. This is true of all automatic sprinkler heads.

During the team audit, several areas were identified in which the licensee applied Criterion 14b (listed in Table 2). The team concludes that corrective actions for all areas in which Criterion 14b was applied to components needed for shutdown should be completed in accordance with the licensee's cable wrap schedule. One example of an area in which Criterion 14b was applied is discussed below. The corrective action is also discussed.

Example: In the auxiliary feedwater pump room redundant equipment and cables are separated by less than 20 feet and are protected by redundant automatic sprinklers. For the reasons stated above, the team concludes that a one-hour barrier should be provided for the cable trays associated with the turbine-driven auxiliary feedwater pump. This corrective action should be completed in accordance with the licensee's cable wrap schedule.

E. Category 5 Criterion

Criterion 10 states that "Relay room cable and equipment and cables in the vicinity of the ceiling of the 460 V switchgear room cannot be passively protected, and, therefore, an alternate shutdown system is required for those areas."

The team agrees with this assumption. An evaluation of the interim acceptability of the licensee's alternate shutdown system follows.

PSE&G has adopted a basic approach to shutdown in the event of fire which involves maintaining operational control from the unit control room as long as it remains habitable. For those plant areas in which a single postulated fire could affect control or operability of redundant equipment, alternative means, through local operation of available equipment, are provided in order to achieve cold shutdown. These alternative means can be applied whether control is maintained in the control room or is transferred to another location in the event, considered unlikely by the licensee, that occupancy of the control room becomes impossible.

PSE&G uses standard functional operating procedures (Operating Instruction I-3.8, Maintaining Hot Standby, Operating Instruction I-3.6, Hot Standby to Cold Shutdown) and Emergency procedures (Emergency Instruction 4.9, Blackout) augmented by Appendices which detail alternative methods of system operation. Explicit instructions for alternative operational methods are provided in a single document, indexed by system, which provides specific local operating procedures for each valve, motor, or component which may be required to be operated in order to achieve cold shutdown or to correct a mis-operation precipitated by fire damage. Each type of local operating instruction was reviewed by the team to confirm technical adequacy. Actual operation of a 4 KV motor, a 460 V motor, a motor operated valve, and an air operated valve were demonstrated using these procedures. Local start of a diesel generator was reviewed for technical adequacy based on a drawing review. Demonstration of this capability was deferred until PSE&G completes a design change in progress to provide alternate control power at each diesel control center. The procedure presently requires pulling temporary cable to provide this alternative.

The team concluded that PSE&G has available sufficient operational information to achieve cold shutdown in any postulated fire which could affect equipment availability or control. The team also concluded that poor organization of the procedures and lack of preplanning were evident which would result in significant lost time were these procedures implemented as currently written.

Accordingly, the team concludes that the following aspects of the alternate shutdown procedure should be required to be corrected prior to Unit 2 operation above 5% rated thermal power. In addition based on the licensee's procedural practices and the commonability of these procedures, these corrective actions should be taken for Unit 1 concurrently. The aspects of the alternate shutdown

procedure that should be corrected are:

- The lack of coordination in the procedures to ensure application of the appropriate alternative method when dictated by plant circumstance or conditions.
- The lack of direction to the Senior Shift Supervisor as to when control room evacuation is dictated, and lack of definition as to which procedures, keys, operator aids, and equipment will be required in the new control location; the lack of discussion of shift organization and personnel deployment for remote operation.
- Most local operating instructions require the use of special equipment or tools. These items are specifically identified in the procedure but have not been pre-staged in a defined location. These items include hand tools, pneumatic jumpers, prepared electrical jumpers, and diesel control power cables.
- No mechanism is provided to maintain system status once local operation has been initiated. No provision to restore normal function to disturbed control systems has been defined.
- No indication of reactor flux level is provided for the dedicated alternate shutdown system. Accordingly, guidance for ensuring or verifying adequate shutdown margin when outside the control room should be provided.
- Dedicated alternate shutdown instrumentation does not include loop or core temperature. For hot standby operation, the licensee plans to use steam generator saturation pressure information to infer primary temperature. In order to achieve cooldown, direct temperature information from the hot and cold legs should be required and can be achieved, if not otherwise available, by installation of temporary instrumentation to the detector lead in the penetration area.
- Only the portable radio/repeater communications systems is identified as immune to the effects of an exposure fire in the relay room. It was determined

during the review that use of a hand-held portable radio to control activities in the plant from the hot shutdown station is extremely difficult due to ambient noise. We conclude that adequate measures should be implemented to ensure that effective communications with that station can be established.

- A single exposure fire in the Relay Room can precipitate a total loss of station lighting. We conclude that adequate 8 hour emergency lighting, independent of plant power systems should be installed at all locations which may be required to be manned during the alternate shutdown procedure as well as at all avenues of entrance to and egress from those areas.
- In order to account for personnel requirements to support unaffected unit operation, the fire brigade, and alternate shutdown functions on the affected unit, 18 shift members were identified. Minimum staffing requirements presently do not include all of the following individuals; 2 Senior Reactor Operators, 4 Nuclear Control Operators, 10 Equipment/Utility Operators, the Shift Technical Advisor, and one maintenance electrician. This staffing level is necessary, on shift, to support a workable alternate shutdown capability. This would necessitate adding an additional two people not currently on shift.

Completion of the above listed corrective actions should be verified by the Office of Inspection and Enforcement prior to Unit 2 operation above 5% rated thermal power.

In addition, in order to fully validate the licensee's capability to accomplish remote shutdown and cooldown, the team concludes that it is necessary for the licensee to perform a demonstration during the performance of Startup Procedure SUP 82.5, Shutdown From Outside Control Room. The following additional operations should be required during that test;

- Local start of diesel generator using alternative control power source.

- Local operation of 4 KV breaker.
- Local start of the containment fan cooler unit.
- Local operation of a motor operated and an air operated valve.
- Local control of charging.

III. Additional Considerations

In a recent letter to NRC the licensee indicated that all cable wrap operations at Unit 2 would be completed in June 1981. In view of the teams findings which indicates additional barriers should be provided in certain areas, the licensee should re-examine the cable wrap schedule and provide the NRC with a new date for completion of wrapping which would include the additional areas identified by the team.

In a letter to NRC the licensee confirmed that response to Generic letter 81-12, "Fire Protection Rule," would be provided by May 19, 1981. The team recognizes that the licensee's staff interaction with the team and the findings of the team will impact the licensee's ability to meet that date. Therefore, the licensee should re-examine the schedule for responding to Generic Letter 81-12 and provide the NRC with a new date for that response.

In addition, OIE recently sent a letter to PSE&G which requires that overall program verification be completed by June 5, 1981. If the team findings have impacted this schedule, a letter should be sent to OIE indicating the licensee's proposed new schedule for completing this action.

IV. Summary

The team concludes that fire protection measures are adequate for continued operation of Unit 1 and for issuance of a license with appropriate license conditions for Unit 2 with the understanding that the corrective actions discussed above would be implemented on a schedule that would be subject to staff approval.

TABLE 1

Licensee Assumptions or Criteria

1. The design basis fire has a 20 foot diameter zone of influence and has a zone of influence that extends from the floor to the ceiling
2. The intensity of the postulated fire decreases with height provided that no combustibles are present within the zone of influence.
3. If horizontal filled cable trays are present within and/or above the 20 foot diameter zone of influence of the fire, the zone of influence is extended out, in a cone shape configuration to include these combustibles.
4. The design basis fire originates from a transient combustible on the floor and is assumed to be 2-4 feet high. Heat will not be transmitted horizontally above the eight foot fire barrier. The zone of influence is truncated at the barrier.
5. Cable will burn, but does not support combustion. Therefore, there is assumed to be no further propagation of fire along a horizontal cable tray once the fire source is removed.
6. Conduit, although not considered to be a combustible, was also not considered to provide a fire barrier to its enclosed cables.
- 8a. The primary fire suppression system in an affected area is assumed to fail.
- 8b. An automatic primary fire suppression system does not have to be provided for redundant safety systems within a fire zone of influence of 20 feet.
9. Cable - initiated fires are not credible.
10. Relay room cable and equipment and cables in the vicinity of the ceiling of the 460 V switchgear room cannot be passively protected, and, therefore, an alternate shutdown system is required for those areas.

11. Manual fire-fighting techniques only are required for the control room since the control room is constantly manned.
12. An exposure fire inside containment is not credible. However, electrical penetrations will be protected by a radiant heat shield. In addition, fire protection is being provided for the RCPs.
13. All AFW trains will be protected that are within the 20 foot zone of influence of the fire.
14. One of the following protective measures is sufficient:
 - a) A one-hour fire barrier between redundant components within a fire area.
 - b) Redundant suppression systems.
 - c) A 1 1/2 hour barrier on ventilation ducts that go through a 3-hour barrier separating redundant systems.

TABLE 2

FURTHER EXAMPLES OF AREAS REQUIRING ADDITIONAL PROTECTION

1. Category 3, Criterion 1

- a. Redundant cables, associated with power, instrumentation, and control for the diesel generators (located in proximity of the diesel generators) were routed within 20 feet of their redundant counterpart. A one-hour barrier around one of the cables was not provided in accordance with the licensee's criteria. These cables should be wrapped in accordance with the licensee's criteria and cable wrap schedule.
- b. Smoke detectors are not provided in the area of the power feeds to redundant diesel generators in the 4 ft. wide hallway near the waste gas tanks. Smoke detectors should be installed on a schedule to be proposed by the licensee.
- c. Redundant cables supplying power to the 4 KV switchgear from the diesel generators are located within 20 feet of each other in the 4 KV switchgear room. These cables should be wrapped in accordance with the licensee's criteria and cable wrap schedule.
- d. Redundant cables supplying power from the 230 volt switchgear to the battery chargers are not wrapped and are within the 20 foot fire zone. These cables should be wrapped in accordance with the licensee's criteria and cable wrap schedule.

3. Category 4, Criterion 8b

The following areas where identified during our review as having manual suppression systems for the protection of redundant equipment.

- a. electrical penetration area
- b. 460-230 volt switchgear room
- c. the deluge system for the fuel oil storage tank room
- d. the hall below the diesel generator rooms where redundant power feed to diesels cross
- e. 4160 volt switchgear room

We find the manual suppression acceptable on an interim basis, pending NRC staff review of the licensee's (Appendix R) exemption

4. Category 4, Criterion 14b

- a. Redundant power cables from the diesel generators located in the fuel oil storage tank room are separated by more than 20 feet but the fixed fire load of diesel fuel oil necessitates a larger than 20 foot separation. Thus, one of the redundant cables should be wrapped in accordance with the licensee's cable wrap schedule.
- b. A one hour fire barrier should be provided the 207 panel or the turbine driven auxiliary feedwater control cabinet in accordance with the licensee's cable wrap schedule.
- c. A one hour fire barrier should be provided for the remote shutdown panel in accordance with the licensee's cable wrap schedule.

2. Category 4, Criterion 4

- a. Barriers separating equipment needed for shutdown should be raised so that the top of the barrier is above the top of the redundant raceways or both redundant raceways should be wrapped. One of the above corrective actions should be completed in accordance with the licensee's cable wrap schedule for the following areas: 460-230 volt switchgear, 125 volt D-C switchgear, the valve motor control centers located in the electrical penetration area, and the pressurizer heater buses located in the electrical penetration area.
- b. In order to minimize the effects of fire and water from fire hoses on redundant equipment, barriers should be extended in an "L" shape configuration and be installed in accordance with the licensee's cable wrap schedule.

Equipment identified during our review that require extended barriers include: the 4160 volt switchgear, 460-230 volt switchgear, the 125 V DC switchgear, the valve motor control centers, and the pressurizer heater buses.

MEETING SUMMARY DISTRIBUTION

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