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GOOD COPIES OF:

1) EFA FOR SLC

2) REPORTABILITY EVALUATION
FOR CARD 99-13518

3) FERMI 2 UFSAR - SLC
4.5.2.4
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4) FERMI 2 TECH SPECS: ~~[illegible]~~
3.1.5 SLC
3.8.4.5 SLC
3.8.1.1 AC SOURCES

JUN 7 1999

JOE LARIZZA

P.S. + TRAVEL VOUCHER THANKS!

C/4

Engineering Functional Analysis for Standby Liquid Control System with Non-Operational Continuity Indication

May 5, 1999

Identification of Degraded Condition

Drawing 6I721-2131-01 "Schematic Diagram Standby Liquid Control Pumps C4103-C001A & B" details the electrical circuit which includes the explosive 'squib' valve bridgewire elements and their associated continuity verification circuits. The continuity circuits are designed to verify squib valve integrity by trickling low amperage current through the squib elements and provide indication on the C41-M600A & B meters on the H11-P613 Panel located in the Relay Room.

Annunciation of the Ignition Continuity Loss alarm indicated that a problem existed within the continuity verification circuits, and the fuse designated F-4 (Grid location D-6 on the drawing) was found to be open. The replacement fuse immediately opened also, preventing the normal function of the continuity verification circuit. The normal function of the circuit is to verify the continuity of the squib elements of the C4104-F004B exists, and this function was lost.

Description of Functions

The SLC System provides an alternate method to shutdown the Reactor independently of the Control Rod Drive (CRD) System. It ensures Reactor shutdown from full power operation to cold sub-critical by mixing a neutron absorber with the primary Reactor coolant. The system is designed for the condition when no Control Rods can be inserted from full power. The neutron absorber is injected within the core zone in sufficient quantity to provide a margin for leakage or imperfect mixing. The SLC System is not a scram or backup scram system for the Reactor, but is an independent backup for the CRD System.

During normal Reactor operation the SLC System is kept on standby. There is no requirement for the SLC System to be operated. The SLC System will be activated only if the CRD System fails.

Operability Determination

The condition as described above discusses the loss of fuse F-4 which is rated for 0.25 Amps (250 milliAmps). Investigation of the circuit schematic reveals that the fault causing the over-current condition at fuse F-4 is connected to the circuit containing the elements by two 13 kiloOhm (kΩ) resistors (R2 and R8 on the circuit schematic). The continuity verification circuit normally operates at amperage levels of ~ 5 milliAmps (mA) as produced by the 120 Volt supply potential delivered across these 2 series-arranged 13 kΩ resistors.

The >250 mA current necessary to open the F-4 fuse must be the result of a short occurring between the F-4 fuse and the R2 resistor. A fault occurring inside the boundaries of the R2 and R8 that could challenge the squib elements (nominally rated at 2 Amps) could not produce the current necessary to open the F-4 fuse because of the current limiting provided by the R2 and R8 resistors.

Troubleshooting performed by I&C technicians has verified this analysis with the determination that meter C41-M600B exhibits improper electrical testing characteristics when compared to a new meter, and it is located between the F-4 fuse and the R2 resistor. Correct continuity through the squib elements was also verified by the I&C technicians. The existence of the short does not affect the function of the SLC System to actuate when required because the short is isolated from the actuation current path by the same 13 kΩ resistors described above. Under the current condition the continuity of the squib elements has been verified and the system operability is unaffected.

Justification for Continued Safe Operation
The SLC system is operable because measurements taken during troubleshooting verified squib circuit continuity and therefore assured squib valve circuit integrity.

In addition, the troubleshooting activities strongly suggest a fault in the meter circuit. This fault will not prevent the ability of firing the squib valves because current is limited by the two 13 kΩ resistors.

Therefore, the SLC System is considered operable in spite of the deficiency of the squib continuity monitoring circuit.

Recommended Plant Action
Replace defective meter C41-M600B as soon as practical following completion of the EDG #11 outage.

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Reportability Evaluation for CARD 99-13518

Summary

On May 5, 1999, EDG 11 was out of service with Standby Liquid Control System (SLCS 'B') equipment powered from the opposite division also declared inoperable. The breaker for SLCS 'B' had been tagged open to permit repairs to the continuity circuits for the SLCS explosive actuated valves. The NRC resident inspectors questioned the plant being in this condition in view of the requirement of Technical Specification (TS) Action 3.8.1.1.c. With one EDG inoperable, TS Action 3.8.1.1.c requires verification of the operability of all "required" equipment powered by the opposite division.

This condition did not constitute a condition prohibited by TS. The basis for this position is twofold.

1. SLCS is not a required system in the context of Action 3.8.1.1.c. SLCS is a unique system. SLCS is not credited in the mitigation of any design basis accident or transient, as opposed to other TS systems such as ECCS systems for which the TS Action 3.8.1.1.c verification is required.

2. SLCS is a manually actuated system. Under the conditions associated with this event, SLCS 'B' was capable of prompt manual restoration. Consequently, SLCS 'B' could have been considered operable.

"Required" within the Scope of TS Action 3.8.1.1.c

SLCS is an unique system. SLCS is the secondary reactivity control system required to satisfy 10 CFR 50, Appendix A GDC 26, *Reactivity control system redundancy and capability*. It is also required by 10 CFR 50.62, the ATWS rule. Two objectives are delineated for the SLCS in the bases for TS 3.1.5, Standby Liquid Control System. One objective is to provide backup capability for bringing the reactor from full power to a cold, Xenon-free shutdown, assuming that the withdrawn control rods remain fixed in the rated power pattern. The second objective of the SLC System is to meet the requirement of the ATWS Rule, specifically 10 CFR 50.62 paragraph (c)(4) which states that, in part: "Each boiling water reactor must have standby liquid control system (SLCS) with a minimum flow capacity and boron content equivalent in control capacity to 86 gallons per minute of 13 weight percent sodium pentaborate solution.

SLCS is not credited in the mitigation of any design basis accident or transient. In BWRs primary automatic ATWS protection is provided by Alternate Rod Insertion (ARI) and the Recirculation Pump Trip (RPT). SLCS was not required to be automatically actuated. ATWS is not a design basis transient.

SLCS was not designed as a safety-related system; however, 10 CFR 50.62, requires SLCS to perform its function in a reliable manner. Although it was not designated as safety-related, it is essentially maintained as such at Fermi. Standby power is a design feature provided for SLCS as discussed in the which states that SLCS "is required to be operable in the event of a station power failure." Accordingly, SLCS pumps, valves, and controls are powered from the standby ac power supply. While the power supplies are oriented to redundant SLCS components, SLCS is not treated as a divisionalized system. Operating, surveillance, and maintenance procedures are not divisionalized. SLCS outages are scheduled during non-divisional work weeks. SLCS is not modeled as a divisionalized system in the Fermi PSA. The Fermi Regulatory Guide 1.47, Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems, has only one status indicator of SLCS, whereas divisionalized safety systems have one for each division.

10 CFR 50, Appendix A, General Design Criteria, Criterion 17, *Electric power systems*, delineates the requirements for on-site and off-site electrical power systems. GDC 17 requires both an on-site and off-site power distribution system to permit functioning structures, systems, and components important to safety, assuming either the on-site or off-site system is unavailable. GDC 17 further defines the two required safety functions supported by the electric power system: 1) protection of specified acceptable fuel design limits and the reactor coolant pressure boundary during anticipated operational occurrences; and, 2) assurance of core cooling and containment integrity during postulated accidents. Both of these functions relate to design basis accidents and transients. In contrast, for beyond design basis ATWS events, 10 CFR 50.62 requires SLCS to be designed to perform its function in a reliable manner. Regulatory Guide 1.93, Availability of Electric Power Sources, provides guidance on TS allowed out of service times for electric power systems required by GDC 17. RG 1.93 frames its discussion in terms of mitigation of design basis accidents and transients.

Technical Specifications Action 3.8.1.1.c states:

c. With one or both diesel generators in one of the above required onsite A.C. electrical power divisions inoperable, in addition to ACTION b, above, verify within 2 hours that all <u>required</u> systems, subsystems, trains, components and devices that depend on the remaining onsite A.C. electrical power division as a source of emergency power are also OPERABLE; otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

A footnote on Action 3.8.1.1.c exempts the primary containment oxygen monitoring instrumentation subject to TS 3.3.7.5 from this requirement.

The bases for TS 3.8.1 indicates that "required" means more than merely being subject to a TS LCO. A "required" system must also be considered a "critical" system where a loss of offsite power under the conditions prohibited by TS Action 3.8.1.1.c would result in a complete loss of a safety function. The bases for TS 3.8.1 states:

> When one diesel generator is inoperable, there is an additional ACTION requirement to verify that all required systems, subsystems, trains, components

and devices, that depend on the remaining OPERABLE diesel generator as a source of emergency power, are also OPERABLE. This requirement is intended to provide assurance that a loss of offsite power event will not result in a complete loss of safety function of critical systems during the period one of the diesel generators is inoperable.

10 CFR 50.36, *Technical Specifications,* establishes requirements for technical specifications and establishes specific criteria which define the required scope and content of the technical specifications. The criteria provide some insight as to what constitutes a "critical system." 10 CFR 50.36(c)(2)(ii) requires that technical specifications limiting conditions for operation be established for items meeting any of the following criteria:

Criterion 1. Installed instrumentation that is used to detect, and indicate in the control room, a significant abnormal degradation of the reactor coolant pressure boundary.

Criterion 2. A process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.

Criterion 3. A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to a fission product barrier.

Criterion 4. A structure, system, or component which operating experience or probabilistic risk assessment has shown to be significant to public health and safety.

These criteria were developed by the NRC and industry during the mid-1980's as part of the Technical Specifications Improvement Project (TSIP). The first three criteria first appeared in the NRC Proposed Policy Statement on Technical Specifications Improvements for Nuclear Power Reactors, published in the Federal Register on February 6, 1987 (52FR3788). The proposed policy statement recognized that the SLCS would not satisfy any of the three criteria for inclusion in Technical Specifications. Of particular note is Criterion 3. SLCS is not part of the primary success path for any design basis accident or transient. Nor is SLCS on the primary success path for beyond design basis ATWS events. In an ATWS event, SLCS would be initiated if the primary path, RPT and ARI, were unsuccessful. However, the proposed policy statement identified SLCS, Reactor Core Isolation Cooling, Residual Heat Removal, and the Recirculation Pump Trip as systems which operating experience and probabilistic risk assessment have generally shown to be important to the public health and safety, a basis similar to the current Criterion 4. The final Policy Statement was published on July 22, 1993 (58FR39132). The final Policy Statement included the current Criterion 4.

All of the systems that are on the primary success path in the mitigation of design basis accidents and transients satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii). This includes the on-site and off-site A.C. sources required by GDC 17 under TS 3.8.1.1, as well as the systems necessary to mitigate design basis accidents and transients. SLCS is a Criterion 4 system. Furthermore, even if SLCS were considered to be a Criterion 3 system (suppose ATWS was considered a design basis transient), SLCS would not be on the primary success path for mitigation of an ATWS event.

The background discussion relating to the evolution of Criterion 4 indicates that it is intended to include systems that "operating experience and probabalistic risk assessment have generally shown to be important to public health and safety." It is noteworthy that the Fermi plant specific PSA and Configuration Risk Management Program mandated by TS 3.8.1.1, shows that removal of the entire SLCS in conjunction with an EDG is a low risk evolution. The PSA models SLCS as a whole, that is not divisionalized. This is consistent with scheduling of maintenance for SLCS and the structure of SLCS related procedures..

The Improved Technical Specifications and associated basis further amplify the significance of Criterion 3 versus Criterion 4 in defining critical or required systems in the context of TS 3.8.1.1. ITS LCO 3.8.1 Action A.2 is analogous the TS Action 3.8.1.1.c in the current TS. The ITS bases for LCO 3.8.1 reiterates the fact that the TS requirements are related to mitigation of design basis accidents and transients. It follows that the required features that must be verified under ITS LCO 3.8.1 Action A.2 (and current TS Action 3.8.1.1.c) comprise the Criterion 3 systems included in TS. SLCS does not rise to the level of systems required by Criterion 3, which require verification under TS Action 3.8.1.1.c when an EDG is out-of-service.

<u>SLCS B was Capable of Performing its Specified Functions</u>

SLCS is a manually actuated system which is credited with two backup functions as described above and in the bases for TS 3.1.5. SLCS "B" was removed from service under LCO 99-0197 because of the loss of the continuity indication for the squib "B" circuit. An Engineering Functional Analysis subsequently determined that operability was unaffected in this configuration. At 1830 hrs on 5/4/99, the MCC position for SLCS "B" was tagged out to provide personnel protection for corrective maintenance on the SLCS "B" continuity circuit. This occurred during the same time that EDG 11 was out-of-service. EDG 11 would provide standby power for SLCS "A." No work was performed on SLCS "B" that would have prevented SLCS "B" from being restored by simple manual action of restoring the breaker at the MCC. The fundamental difference in this configuration is that activation of SLCS "B" in a loss-of-offsite power scenario would require an additional manual action outside the control room at the MCC. Restoration of the breaker for SLCS "B" under non-emergency circumstances took 17 minutes on 5/5/99 when NRC questioned the situation with EDG 11 and SLCS "B" both inoperable. Indications are that SLCS "B" could have been restored in significantly less time had an emergency existed necessitating its activation. Since SLCS is a manually actuated system, the additional manual action in an accessible area outside the control room would not have prevented SLCS 'B' from performing its specified function.

Generic Letter 91-18 (NRC Inspection Manual Part 9900, Operable/Operability: Ensuring the Functional Capability of a System or Component) provides guidance on determining operability for degraded and non-conforming conditions. Although, this guidance was not applied at the time the SLCS "B" breaker was opened, it can be applied retrospectively to assess whether or not a condition prohibited by TS actually existed. The central focus of this guidance is whether or not SLCS "B" was capable of performing its intended functions.

As discussed above, two functions are attributed to SLCS. The first relates to the GDC 26 function of providing a redundant reactivity control system, the primary function for SLCS described in the UFSAR. As discussed in the UFSAR, this function is not time critical. The second function relates to the 10 CFR 50.62 ATWS rule requirements for SLCS. No plant specific ATWS analysis is presented in the UFSAR. The ATWS rule prescribes overall functional requirements for SLCS based on generic analysis of ATWS events. The UFSAR to references General Electric topical reports (primarily NEDE-24222, December 1979) relating to ATWS.

The generic ATWS evaluation assumes the beyond design basis failure of the RPS to initiate a reactor trip in conjunction with the anticipated operational occurrences described in the UFSAR. The primary success path for ATWS is the automatic Recirculation Pump Trip (RPT) and Alternate Rod Insertion (ARI). The generic evaluation indicates that RPT results in a immediate substantial reduction in power into the 20-30% range. ARI provides a diverse method from RPS for initiating control rod insertion. SLCS would only be necessary if ARI was unsuccessful. The generic evaluation conservatively assumes ARI failure and relies on the backup SLCS. The generic evaluation assumes that SLCS is initiated at two minutes into the ATWS event. The reactor becomes subcritical in less than fifteen minutes.

For the situation considered in this CARD, the relevant ATWS transient involves a loss-of-offsite power. The LOOP results in closure of MSIVs and loss of the condenser as a heat sink. In this scenario all of the heat generated by the reactor is deposited in the suppression pool, resulting in suppression pool heat up and containment pressurization. The effect of having the SLCS "B" breaker open at the MCC would be to delay SLCS initiation by up to about 15 minutes. A simple energy balance on the containment indicates that the containment design pressure would not be exceeded assuming a 15 minute delay in initiating SLCS. The containment emergency pressurization limit should not be exceeded for and ATWS event. The energy balance assumes that all of the steam relieved into the suppression pool is condensed and that the pool mass increase associated with the condensed steam is negligible. No credit is taken for suppression pool cooling. It is expected that a more rigorous analysis would continue to support the conclusion that the containment pressurization limit would not be exceeded and that SLCS "B" was capable of performing its specified function for ATWS mitigation, and could have been considered operable.

more gadolinium than others to improve transverse power flattening. Also, some assemblies contain axially distributed gadolinium to improve axial power flattening. For a detailed discussion of gadolinia fuels, refer to Subsection 4.3.2.

4.5.2.3.3 Safety Evaluation

The description shows that the gadolinia-urania fuel rods meet the design-basis requirements (Subsection 4.3.2).

4.5.2.3.4 Inspection and Testing

The same rigid quality control requirements observed for standard UO_2 fuel are employed in manufacturing gadolinia-urania fuel. Gadolinia-bearing UO_2 fuel pellets of a given enrichment and gadolinia concentration are maintained in separate groups throughout the manufacturing process. The percent enrichment and gadolinia concentration characterizing a pellet group are identified by a stamp on the pellet.

Fuel rods are individually numbered prior to loading of fuel pellets into the fuel rods for three reasons: to identify which pellet group is to be loaded in each fuel rod, to identify which position in the fuel assembly each fuel rod is to be loaded into, and to facilitate total material accountability for a given project. For the initial core, longer upper end plug shanks for gadolinia-bearing rods ensured their correct placement within the fuel assembly. For reload cores, a uniform end plug is used for all rods. Correct placement is ensured by an automated bundle assembly machine.

The following QC inspections are made.

a. Gadolinia concentration in the gadolinia-urania powder blend is verified

b. Sintered pellet UO_2-Gd_2O_3 solid-solution homogeneity across a fuel pellet is verified by examination of metallographic specimens

c. Gadolinia-urania pellet identification is verified

d. Gadolinia-urania fuel rod identification is checked.

All assemblies and rods of a given project are inspected to ensure overall accountability of fuel quantity and placement for the project.

4.5.2.4 Standby Liquid Control System

4.5.2.4.1 Design Bases

The standby liquid control system (SLCS) is a special-event plant capability system and is tested and maintained as a safety-related system. The system is designed with a high degree of reliability and with certain safety features; however, it is not required to meet the safety design-basis requirements of the safety systems.

The SLCS shall meet the following design bases:

a. Backup capability for reactivity control shall be provided, independent of normal reactivity control provisions in the nuclear reactor, to be able to shut down the reactor if the normal control ever becomes inoperative

b. The backup system shall have the capacity for controlling the reactivity difference between the steady-state rated operating condition of the reactor with voids and the cold shutdown condition, including shutdown margin, to ensure complete shutdown from the most reactive condition at any time in core life

c. The time required for actuation and effectiveness of the backup control shall be consistent with the nuclear reactivity rate of change predicted between rated operating and cold shutdown conditions. A fast scram of the reactor or operational control of fast reactivity transients is not specified to be accomplished by this system

d. Means shall be provided by which the functional performance capability of the backup control system components can be verified periodically under conditions approaching actual use requirements. A substitute solution, rather than the actual neutron absorber solution, can be injected into the reactor to test the operation of all components of the redundant control system

e. The neutron absorber shall be dispersed within the reactor core in sufficient quantity to provide a reasonable margin for leakage or imperfect mixing

f. The system shall be reliable to a degree consistent with its role as a control system; the possibility of unintentional or accidental shutdown of the reactor by this system shall be minimized.

4.5.2.4.2 <u>Description</u>

The SLCS (Figure 4.5-17) is manually initiated from the main control room to pump a boron neutron absorber solution into the reactor if the operator believes the reactor cannot be shut down or kept shut down with the control rods. However, insertion of control rods is expected to ensure prompt shutdown of the reactor should it be required.

The SLCS is required only to shut down the reactor and keep the reactor from going critical again as it cools.

The SLCS is needed only in the improbable event that not enough control rods can be inserted in the reactor core to accomplish shutdown and cooldown in the normal manner.

The storage tank and active portion of the SLCS necessary for the injection of boron have been reclassified to identify that the SLCS was not originally intended, procured, designed, or classified as safety related, but is being maintained and tested as a safety-related system after completion of its preoperational tests.

The boron solution tank, the test water tank, the two positive-displacement pumps, the two explosive valves, and associated local valves and controls are mounted in the reactor building. The liquid is piped into the RPV and discharged near the bottom of the core shroud so it mixes with the cooling water rising through the core (Subsection 4.5.1.2 and Figure 4.5-2).

The boron absorbs thermal neutrons and thereby terminates the nuclear fission chain reaction in the uranium fuel.

The specified neutron absorber solution is enriched sodium pentaborate ($Na_2B_{10}O_{16} \cdot 10H_2O$) dissolved in demineralized water. An air sparger is provided in the tank for mixing. To prevent system plugging, the tank outlet is raised above the bottom of the tank.

Whenever it is possible to make the reactor critical, the SLCS shall be able to deliver enough sodium pentaborate solution into the reactor (Figure 4.5-18) to ensure reactor shutdown. This is accomplished by placing the required amount of sodium pentaborate in the standby liquid control tank and filling with demineralized water to at least the low-level alarm point.

The saturation temperature of the recommended solution is approximately 40°F. The SLC tank is installed in a room in which the air temperature is to be maintained within the range of 70°F to 100°F. High or low temperature, or high or low liquid level, causes an alarm in the main control room.

The lines and equipment from the storage tank to the explosive valves are insulated.

The SLCS is completely contained within the reactor building. This building is well heated and ventilated; it also receives most of the heat loss from the reactor system. It is therefore incredible for the water in the SLCS to freeze while the plant is operating.

Each positive displacement pump is sized to inject the solution into the reactor in 50 to 125 minutes, independent of the amount of solution in the tank. The pump and system design pressure between the explosive valves and the pump discharge is 1400 psig. The two relief valves are set slightly under 1400 psig. To prevent bypass flow from one pump in case of relief valve failure in the line from the other pump, a check valve is installed downstream of each relief valve line in the pump discharge pipe.

The two explosive-actuated injection valves provide assurance of opening when needed and ensure that boron does not leak into the reactor even when the pumps are being tested.

Each explosive valve is closed by a plug in the inlet chamber. The plug is circumscribed with a deep groove so the end readily shears off when pushed with the valve plunger. This opens the inlet hole through the plug. The sheared end is pushed out of the way in the chamber; it is shaped so it does not block the ports after release.

The shearing plunger is actuated by an explosive charge with dual ignition primers inserted in the side chamber of the valve.

Ignition circuit continuity is monitored by a trickle current, and an alarm occurs in the main control room if either circuit opens. Indicator lights show which primary circuit opened.

The SLCS is actuated by a three-position keylocked switch on the main control room console. This ensures that switching from the "off" position is a deliberate act. Switching to either side starts an injection pump, actuates both of the explosive valves, and closes the reactor cleanup system outboard isolation valve to prevent loss or dilution of the boron. This action occurs only if the SLC system is lined up normally. If either SLC pump breaker is racked out, only one pump and explosive actuated injection valve will operate.

A green light in the main control room indicates that power is available to the pump motor contactor and that the contactor is open (pump not running). A red light indicates that the contactor is closed (pump running).

If the pump lights or explosive valve light indicate that the liquid may not be flowing, the operator can immediately turn the switch to the other side, which actuates the alternative pump.

Cross piping and check valves ensure a flow path through either pump and either explosive valve. The local switch does not have a "stop" position. This prevents the separation of the pump from the main control room. Pump discharge pressure is also indicated in the main control room.

Equipment drains and tank overflow are not piped to the radwaste system but to separate containers (such as 55-gal drums) that can be removed and disposed of independently to prevent any trace of boron from inadvertently reaching the reactor.

Instrumentation consisting of solution temperature indication, solution level, and heater system status is provided locally at the storage tank.

4.5.2.4.3 Safety Evaluation

The SLCS is a redundant reactivity control system and is maintained in a standby operational status in the reactor modes 1, 2, and 5 when any rod is withdrawn. The system is not expected to be needed for safety reasons because of the large number of independent control rods available to shut down the reactor.

However, to ensure the availability of the SLCS, two sets of pumps and explosive valves are provided in parallel redundancy.

The system is designed to bring the reactor from rated power to a cold shutdown at any time in core life. The reactivity compensation provided reduces reactor power from rated to zero level and allows cooling the nuclear system to room temperature, with the control rods remaining withdrawn in the rated power pattern. It includes the reactivity gains that result from complete decay of the rated power xenon inventory. It also includes the positive reactivity effects from eliminating steam voids, changing water density from hot to cold, reducing Doppler effect in uranium, reducing neutron leakage from boiling to cold, and decreasing control rod worth as the moderator cools. The specified minimum final concentration of boron in the reactor core provides a margin of $-0.026\Delta k$ for calculational uncertainties and ensures subcriticality.

Fermi 2 meets the requirements of 10CFR50.62, ATWS Rule, by increasing the enrichment of boron-10 to a minimum of 65 atom percent. The current design of the SLC system is sufficient to handle the increased enrichment of sodium pentaborate solution because the enriched boron solution is chemically similar to the current solution. Using an enriched solution will not change any of the key SLC system process parameters, i.e., flow rate, discharge pressure, required NPSH, etc.

The specified minimum average concentration of natural boron in the reactor to provide the specified shutdown margin, after operation of the SLCS, is 720 ppm. This value is increased by 25 percent to 900 ppm to allow for imperfect mixing and leakage. Thus, calculation of the minimum quantity of sodium pentaborate to be injected into the reactor is based on 900 ppm average concentration in the reactor coolant, including recirculation loops and the RHR system in the shutdown cooling mode, at 70°F and reactor water Level 8.

Cooldown of the nuclear system requires a minimum of several hours to remove the thermal energy stored in the reactor cooling water and associated equipment. The controlled limit for the RPV cooldown is 100°F per hour, and normal operating temperature is approximately 550°F. Use of the main condenser and various shutdown cooling systems requires 10 to 24 hr to lower the RPV to room temperature (70°F). This is the condition of maximum reactivity and, therefore, the condition that requires the maximum concentration of boron.

The specified boron injection rate is limited to the range of 8 to 20 ppm/minute. The lower rate ensures that the boron is injected into the reactor in approximately 2 hr. This resulting reactivity insertion is considerably quicker than that covered by the cooldown. However, power cyclic oscillations from uneven mixing of boron in the core at high delivery rates is not a concern because of the steady boron concentration buildup observed in mixing tests, as documented in NEDC-30921.

The active portion of the SLCS equipment essential for injection of neutron absorber solution into the reactor is tested and maintained as safety-related equipment.

The SLCS is required to be operable in the event of a station power failure. Therefore, the pumps, valves, and controls are powered from the standby ac power supply. The pumps and valves are powered and controlled from separate buses and circuits.

The SLCS and pumps have sufficient pressure margin, up to the system relief valve setting of approximately 1400 psig, to ensure solution injection into the reactor above the normal pressure in the bottom of the reactor. The nuclear system relief and safety valves begin to relieve pressure above approximately 1100 psig. Therefore, the SLCS positive displacement pumps cannot overpressurize the nuclear system.

Only one of the two standby liquid control pumps and/or explosive actuated injection valves is needed for system operation. If one pump and/or injection valve is found to be inoperable, there is no immediate threat to shutdown capability, and reactor operation and/or rod movement can continue during repairs. The time during which one redundant component upstream of the explosive valves may be out of operation should be consistent with the following: the probability of failure of both the control rod shutdown capability and the alternative component in the SLCS; and the fact that nuclear system cooldown takes several hours while liquid control solution injection takes approximately 2 hr. Since this probability is small, considerable time is available for repairing and restoring the SLCS to an operable condition while reactor operation continues. Assurance that the system will still fulfill its function during repairs is obtained by maintaining the operable status of the redundant pump/valve combination.

Standard Review Plan (SRP) 4.6 states that the SLCS is reviewed by using SRP 9.3.5 to determine its adequacy to perform its function of reactivity control. The following summarizes the comparison of the Fermi 2 SLCS with the acceptance criteria listed in SRP 9.3.5:

a. The system is housed in the reactor building and therefore meets General Design Criterion (GDC) 2 for withstanding natural phenomena

b. The system is located in a missile-free area on the fourth floor of the reactor building. The system piping is studied for pipe whip and jet impingement effects both inside and outside primary containment. These studies show conformance with GDC 4

c. The SLCS meets the requirements for high functional reliability and inservice testability. However, the system design criteria do not specify a single-failure criterion for tanks and piping, but dual pumps and dual explosive valves are incorporated. The reliability criteria are further discussed elsewhere in this section and in Subsection 4.5.2.2.3.4

d. The SLCS is independent of other control systems and is capable of maintaining the core subcritical under cold conditions. Therefore, GDC 26 and GDC 27 are met

e. The classification of system components is given in Table 3.2-1.

f. The location of the SLCS renders it immune to the effects of flooding and tornado missiles. The system meets the criteria for breaks in piping systems outside the drywell.

A discussion in Subsection 4.5.2.2.3.4 addresses the vulnerability of the CRD system and SLCS to common mode failures. The two systems do not share any instrumentation or components. The probability of a common mode failure in the SLCS is dominated by the failure of an operator to actuate the system in a timely manner. The probability of this type of operator error is estimated to be in the range of 1×10^{-1} to 1×10^{-3} per demand, depending on the time required for system activation.

4.5.2.4.4 Inspection and Testing

Operational testing of the SLCS is performed in at least two parts to avoid inadvertently injecting boron into the reactor.

With the valves to and from the storage tank closed and the three valves to and from the test tank opened, demineralized water in the test tank can be recirculated by locally starting either pump.

The injection portion of the system can be functionally tested by valving the pump suction lines to the test tank and actuating the system from the main control room. Both injection valves open on actuation. System operation is indicated in the main control room.

After functional tests, the injection valve shear plugs and explosive charges must be replaced and all the valves returned to their normal positions as indicated.

After closing a local locked-open valve to the reactor, leakage through the injection valves can be determined by opening valves at a test connection in the line between the containment isolation check valves. Position indicator lights in the main control room indicate that the local valve is closed for tests or open and ready for operation. Leakage from the reactor through the first check valve can be detected by opening the same test connection when the reactor is pressurized.

The test tank contains demineralized water for approximately 3 minutes of pump operation. Demineralized water from the makeup system or the condensate storage system is available for refilling or flushing the system.

Should the boron solution ever be injected into the reactor, either intentionally or inadvertently, after it is made certain that the normal reactivity controls will keep the reactor subcritical, the boron is removed from the reactor coolant system by flushing for gross dilution followed by operating the reactor water cleanup (RWCU) system (Subsection 5.5.8). There is practically no effect on reactor operations when the boron concentration has been reduced below approximately 50 ppm.

The concentration of the sodium pentaborate in the solution tank is determined periodically by chemical analysis.

4.5.2.4.5 Instrumentation

The instrumentation and control system for the SLCS is designed
3 to allow the injection of liquid poison into the reactor. The
discussion of the SLCS instrumentation is included in Subsection 7.4.1.

by providing the makeup water. Initiation and control are automatic.

The provisions taken in accordance with General Design Criterion (GDC) 19 of 10 CFR 50, Appendix A, to provide the required equipment outside the main control room for hot and cold shutdown, are described in Subsection 7.5.1.5.1.

7.4.1.1.5.2 Setpoints

A list of setpoints for the RCIC system can be found in Table 7.4-1.

7.4.1.2 Standby Liquid Control System Instrumentation and Control

7.4.1.2.1 System Identification

7.4.1.2.1.1 Function

The instrumentation and control system for the standby liquid control system (SLCS) is designed to inject water-soluble neutron-absorber solution well above saturation temperature.

7.4.1.2.1.2 Classification

The SLCS is a backup method of manually shutting down the reactor to cold subcritical independently from the control rod drive system. Thus, the system is considered a control system and not a safety system. The standby liquid control process equipment, instrumentation, and control essential for injection of the neutron-absorber solution into the reactor are designed to withstand Category I earthquake loads. Nonprocess equipment and instrumentation and control are designed as a nonseismic system. The SLCS has been reclassified to identify that it was not originally intended, procured, designed, or classified as safety related, but it will be maintained and tested as a safety-related system after completion of its preoperational tests.

7.4.1.2.2 Power Sources

The power supply to explosive valve F004A and injection pump C001A is from automatically restored MCC 72B-4C. The power supply to explosive valve F004B and injection pump C001B is from automatically restored MCC 72E-5B. The location of these pumps and valves is shown in Figure 7.4-3. The power supply to the tank heaters and heater controls can also be connected to an engineered safety feature (ESF) bus. The 120-V ac power supply to the main control room benchboard indicator lights is powered from an inductive BOP MPU, and the level and pressure transmitters are powered from restorable instrument MPU 1.

7.4.1.2.3 Equipment Design

7.4.1.2.3.1 Initiating Circuits

The standby liquid control is initiated in the main control room by turning a keylocking switch to either system A or system B. The key is removable in the center OFF position. When either system is initiated, both explosive valves (F004A and F004B) are fired, and the selected pump C001A or C001B is started. Should the selected pump fail to start, the key switch may be turned to the alternate pump.

7.4.1.2.3.2 Logic and Sequencing

When the SLCS is initiated, both the explosive valves fire and the pump that has been selected for injection starts.

7.4.1.2.3.3 Bypasses and Interlocks

There are no bypasses. When the SLCS is initiated to inject soluble neutron absorber into the reactor, the outboard isolation valve of the reactor water cleanup (RWCU) is automatically closed.

7.4.1.2.3.4 Redundancy and Diversity

The redundancy exists in duplicated pumps, explosive valves, and power supply as outlined in Subsection 7.4.1.2.2.

7.4.1.2.3.5 Actuated Devices

When the SLCS is initiated to inject soluble neutron absorber into the reactor, one of the two injection pumps and each of the two explosive valves are actuated.

7.4.1.2.3.6 Testability

The instrumentation and control system of the SLCS is tested when the system test is performed as outlined in Subsection 4.5.2.4.4.

7.4.1.2.4 Environmental Considerations

The environmental considerations for the instrumentation and control portions of the SLCS are the same as for the active mechanical components of the system. This is discussed in Section 3.11 and Subsection 4.5.2.4.3.

7.4.1.2.5 Operational Considerations

7.4.1.2.5.1 General Information

The control scheme for the SLCS can be found in Figure 7.4-3. The standby liquid control is manually initiated in the main control room by inserting the proper key into the keylocking switch and turning it to either system A or system B. The time it takes to complete the injection is between 50 and 125 minutes. When the injection is completed, the system is manually turned off by returning the keylocking switch to the OFF position.

7.4.1.2.5.2 Operator Information

The SLCS indicators are as follows:

a. The system pressure is indicated with an indicator that has a range of 0-1800 psig in the main control room

b. The storage tank level is indicated with an indicator that has a range of near empty to near full, calibrated to read in inches of liquid storage in the main control room | 3

c. The continuity of the explosive valve dual primer ignition circuit is monitored by measuring a trickle current through the primers. If either of the dual primer or the primer ignition circuit becomes open-circuited, the continuity meter reads downscale

d. Indicator lights in the main control room show if either pump is running, stopped, or tripped

e. Indicator lights in the main control room show whether or not the explosive valve firing circuitry has continuity

f. Indicator lights in the main control room show if service valve F008 is open or closed, as shown in Figure 7.4-3

g. Indicator lights in the main control room show if the F006 check valve disk is open or closed

h. Indicator lights on the local panel show if the manually controlled high-power storage tank heater is on or off

i. Indicator lights on the local panel show if the manually controlled low-power storage tank heater is on or off. | 3

The SLCS main control room annunciators annunciate when

a. There is a loss of continuity of either explosive valve primers

b. The standby liquid storage temperature becomes too hot or too cold

c. The standby liquid tank level is too high or too low.

7.4.1.2.5.3 Setpoints

The SLCS has setpoints for the various instruments as follows:

a. The loss of continuity meter is set to activate the annunciator just below trickle current that is observed when the primers of the explosive valves are new

b. The high and low standby liquid temperature switch is set to activate the annunciator at temperatures of approximately 110°F and 48°F, respectively

c. The high and low standby liquid storage tank level switch is set to activate the annunciator when the volume is approximately 2975 gal net and 2618 gal net of the storage tank capacity, respectively

7.4.1.3 Reactor Shutdown Cooling System Instrumentation and Control

7.4.1.3.1 System Identification

The shutdown cooling mode is a function of the RHR system and is placed in operation during a normal shutdown and cooldown.

7.4.1.3.2 Power Sources

The power sources for the reactor shutdown cooling system instrumentation and control are as described in the ECCS discussion in Subsection 7.3.1.2.

7.4.1.3.3 Equipment Design

The reactor water is cooled by taking suction from one of the recirculation loops as shown in Figure 5.5-13. During the shutdown cooling mode, only one RHR system heat exchanger is required. This allows the remaining RHR system division to be held in standby for use in either the low-pressure coolant injection (LPCI) mode or containment cooling mode. One RHR division's valve alignment is shifted from the standby mode lineup (suction from the torus) needed for LPCI and containment cooling to the shutdown mode lineup (suction from reactor recirculation loop-B) after the reactor is depressurized. One RHR heat exchanger removes enough decay heat, even with declining reactor water approach temperature, so that the proper cooldown rate may be achieved.

If it is necessary to discharge a complete core load of reactor fuel to the spent fuel pool, the cooling capacity of the fuel pool cooling and cleanup system (FPCCS) heat exchangers may be exceeded. A means is provided for making a physical connection between the spent fuel pool and the RHR system. The RHR heat exchangers have greater cooling capacity than the FPCCS heat exchangers, and can maintain the spent fuel pool within its

3/4.1.5 STANDBY LIQUID CONTROL SYSTEM

LIMITING CONDITION FOR OPERATION

3.1.5 The standby liquid control system shall be OPERABLE.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, and 5*

ACTION:

a. In OPERATIONAL CONDITION 1 or 2:

  1. With one pump and/or one explosive valve inoperable, restore the inoperable pump and/or explosive valve to OPERABLE status within 7 days or be in at least HOT SHUTDOWN within the next 12 hours.

  2. With the standby liquid control system otherwise inoperable, restore the system to OPERABLE status within 8 hours or be in at least HOT SHUTDOWN within the next 12 hours.

b. In OPERATIONAL CONDITION 5*:

  1. With one pump and/or one explosive valve inoperable, restore the inoperable pump and/or explosive valve to OPERABLE status within 30 days or insert all insertable control rods within the next hour.

  2. With the standby liquid control system otherwise inoperable, insert all insertable control rods within 1 hour.

SURVEILLANCE REQUIREMENTS

4.1.5 The standby liquid control system shall be demonstrated OPERABLE:

a. At least once per 24 hours by verifying that;

  1. The temperature of the sodium pentaborate solution is greater than or equal to 48°F.

  2. The available volume of sodium pentaborate solution is within the limits of Figure 3.1.5-1.

  3. The temperature of the pump suction piping is greater than or equal to 48°F.

*With any control rod withdrawn. Not applicable to control rods removed per Specification 3.9.10.1 or 3.9.10.2.

b. At least once per 31 days by:

1. Verifying the continuity of the explosive charge.

2. Determining that the concentration of boron in solution is within the limits of Figure 3.1.5-1 by chemical analysis.*

3. Verifying that each valve (manual, power-operated, or automatic) in the flow path that is not locked, sealed, or otherwise secured in position, is in its correct position.

c. Demonstrating that, when tested pursuant to Specification 4.0.5, the minimum flow requirement of 41.2 gpm at a pressure of greater than or equal to 1215 psig is met.

d. At least once per 18 months by:

1. Initiating one of the standby liquid control system loops, including an explosive valve, and verifying that a flow path from the pumps to the reactor pressure vessel is available by pumping demineralized water into the reactor vessel. The replacement charge for the explosive valve shall be from the same manufactured batch as the one fired or from another batch which has been certified by having one charge of that batch successfully fired. Both injection loops shall be tested in 36 months.

2. Demonstrating that the pump relief valve setpoint is less than or equal to 1400 psig and verifying that the relief valve does not actuate during recirculation to the test tank.

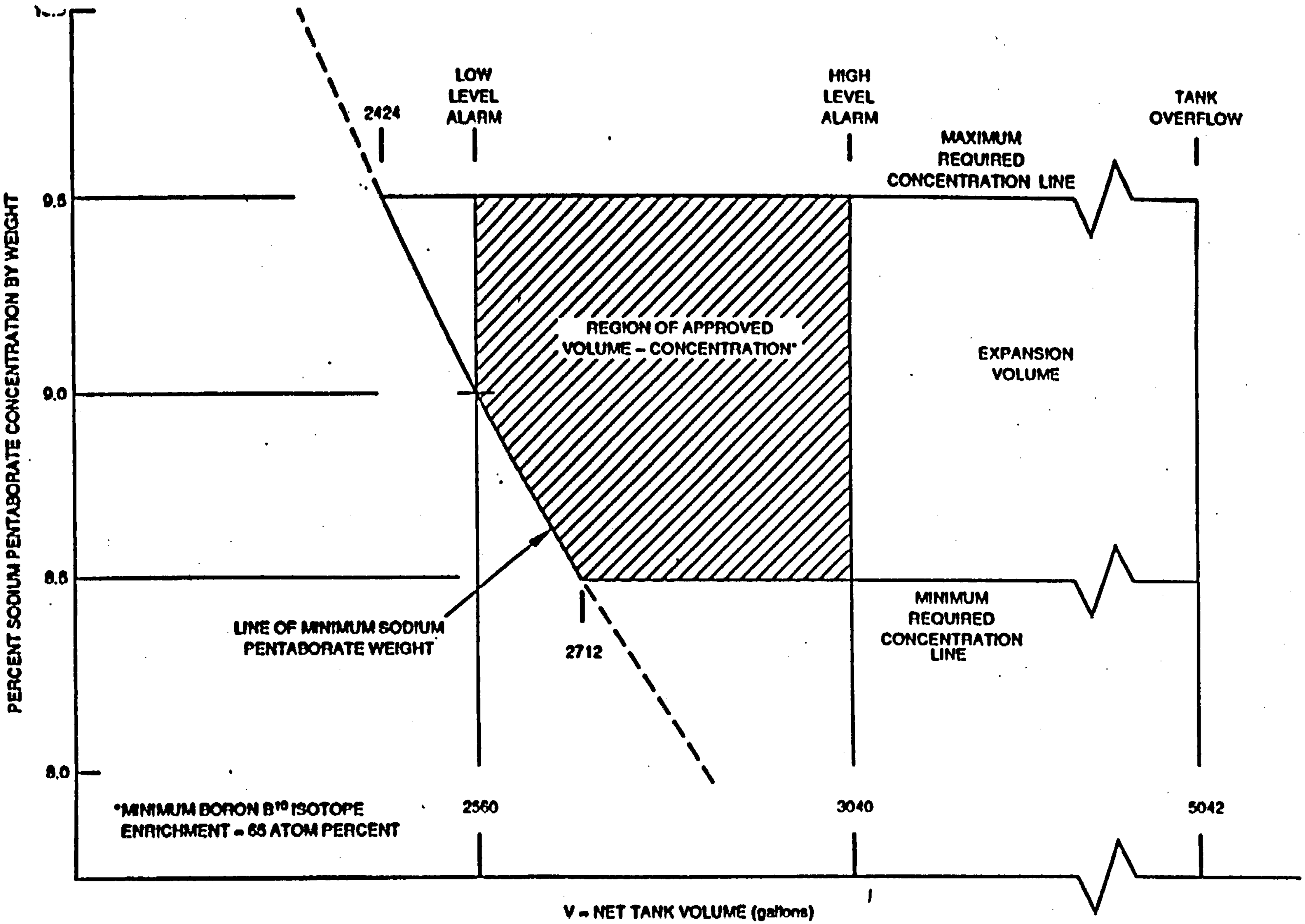
3. Demonstrating that all piping between the storage tank and the explosive valves is unblocked by pumping from the storage tank to the test tank and then draining and flushing the piping with demineralized water.**

4. Demonstrating that the storage tank heaters are OPERABLE for mixing by verifying the expected temperature rise of the sodium pentaborate solution in the storage tank after the heaters are energized.

e. At least once per 18 months sample and analyze the sodium pentaborate solution to verify that the Boron-10 Isotope enrichment exceeds 65 atom percent.

*This test shall also be performed anytime water or boron is added to the solution or when the solution temperature drops below the 48°F limit.

**This test shall also be performed whenever the solution temperature drops below the 48°F limit and may be performed by any series of sequential, overlapping or total flow path steps such that the entire flow path is included.



SODIUM PENTABORATE VOLUME/CONCENTRATION REQUIREMENTS

FIGURE 3.1.5-1

STANDBY LIQUID CONTROL SYSTEM ASSOCIATED ISOLATION DEVICES

LIMITING CONDITION FOR OPERATION

3.8.4.5 All circuit breakers shown in Table 3.8.4.5-1 shall be OPERABLE.

APPLICABILITY: When standby liquid control system (SLCS) is required to be OPERABLE.

ACTION:

With one or more of the circuit breakers shown in Table 3.8.4.5-1 inoperable either:

a. Restore the inoperable circuit breaker(s) to OPERABLE status within 8 hours, or

b. Trip the inoperable circuit breaker(s), rack out or remove the device from service within 8 hours and verify the circuit breaker(s) to be racked out or removed from service at least once per 7 days thereafter, and declare the affected SLCS component inoperable and apply the appropriate ACTION as required by Specification 3.1.5*.

SURVEILLANCE REQUIREMENTS

4.8.4.5 Each of the above required circuit breaker(s) shall be demonstrated OPERABLE:

a. At least once per 18 months by performing a CHANNEL CALIBRATION of the associated protective relays and a CHANNEL FUNCTIONAL TEST of each breaker which includes simulation of actuation of the system and verifying that each relay and associated circuit breaker and overcurrent control circuits functions as designed.

b. At least once per 60 months by subjecting each circuit breaker to an inspection and preventive maintenance in accordance with procedures prepared in conjunction with its manufacturer's recommendations.

*The requirement to apply the appropriate ACTION as required by Specification 3.1.5 is not required for inoperable SLC tank heater circuit breaker(s) provided the other requirements of ACTION 3.8.4.5.b are complied with.

TABLE 3.8.4.5-1

STANDBY LIQUID CONTROL SYSTEM ASSOCIATED ISOLATION DEVICES
480 V MOTOR CONTROL CENTERS

MCC 72B-4C	
Position 2AR	SLC Pump A
MCC 72C-4A	
Position 5C	SLC Heater A
MCC 72E-5B	
Position 2B	SLC Pump B
Position 2CR	SLC Heater B

3/4.8 ELECTRICAL POWER SYSTEMS

3/4.8.1 A.C. SOURCES

A.C. SOURCES - OPERATING

LIMITING CONDITION FOR OPERATION

3.8.1.1 As a minimum, the following A.C. electrical power sources shall be OPERABLE:

a. Two physically independent circuits between the offsite transmission network and the onsite Class 1E distribution system, and

b. Two separate and independent onsite A.C. electrical power sources, Division I and Division II, each consisting of two emergency diesel generators, each diesel generator with:

   1. A separate day fuel tank containing a minimum of 210 gallons of fuel,

   2. A separate fuel storage system containing a minimum of 35,280 gallons of fuel, and

   3. A separate fuel transfer pump.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, and 3.

ACTION:

a. With one or both offsite circuits of the above required A.C. electrical power sources inoperable, be in at least HOT SHUTDOWN within 12 hours and in COLD SHUTDOWN within the next 24 hours; demonstrate the OPERABILITY of the remaining A.C. sources by performing Surveillance Requirement 4.8.1.1.1. within one hour and at least once per 8 hours thereafter and,

b. With one or both diesel generators in one of the above required onsite A.C. electrical power divisions inoperable;

   1. Demonstrate the OPERABILITY of the remaining A.C. sources by performing Surveillance Requirement 4.8.1.1.1 within one hour and at least once per 8 hours thereafter, and if the diesel generator(s) became inoperable due to any cause other than an inoperable support system, an independently testable component, or preplanned preventive maintenance or testing, by performing Surveillance Requirement 4.8.1.1.2.a.4 for one diesel generator at a time within 24 hours, unless the absence of any potential common mode failure for the remaining diesel generators is determined, and

ACTION (Continued)

2. Verify within 8 hours and at least once per 8 hours thereafter, that CTG 11-1 is OPERABLE. Restore the inoperable division to OPERABLE status within 7 days or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

3. If the requirements of ACTION b.2. above for CTG 11-1 cannot be met, either restore the inoperable division to OPERABLE status within 72 hours (not to exceed 7 days from the time the division became inoperable); or, satisfy the requirements of ACTION b.2 above within 72 hours and restore the inoperable division to OPERABLE status within 7 days from the time the division became inoperable; or, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

c. With one or both diesel generators in one of the above required onsite A.C. electrical power divisions inoperable, in addition to ACTION b. above, verify within 2 hours that all required systems, subsystems, trains, components and devices* that depend on the remaining onsite A.C. electrical power division as a source of emergency power are also OPERABLE; otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

d. With both of the above required onsite A.C. electrical power divisions inoperable:

1. Demonstrate the OPERABILITY of the remaining A.C. sources by performing Surveillance Requirement 4.8.1.1.1 within one hour and at least once per 8 hours thereafter; and

2. Restore at least one of the above required inoperable divisions to OPERABLE status within 2 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours; and

3. Restore the second of the above required divisions to OPERABLE status within the time required by Action b above from the time of initial loss or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

*Except for an inoperable primary containment oxygen monitoring instrumentation channel, required by Specification 3.3.7.5, that depends on the remaining OPERABLE onsite A.C. electrical power division. In this case, take the ACTION required by Specification 3.3.7.5 for the inoperability of both required primary containment oxygen monitoring instrumentation channels.