Nebraska Public Power District
Nebraska's Energy Leader

NLS2001034
March 22, 2001

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Gentlemen:

Subject: Information Related to Preliminary Finding
NRC Inspection Report No. 50-298/00-07
Cooper Nuclear Station, NRC Docket 50-298, DPR-46

References:

1. Letter to J. H. Swailes (NPPD) from K. E. Brockman (NRC) dated December 18, 2000, "Cooper Nuclear Station Special Inspection - NRC Inspection Report 50-298/00-07; Preliminary Yellow Finding."

2. Notice of Licensee Meeting, March 8, 2001, re: Regulatory Conference to Discuss Risk Significance of Preliminary Finding Identified in NRC Inspection Report 50-298/00-07.

Reference 1 describes a preliminary finding resulting from a Nuclear Regulatory Commission (NRC) special inspection evaluating the Cooper Nuclear Station (CNS) environmental qualification (EQ) program. As encouraged in Reference 1, the attachment to this letter provides the Nebraska Public Power District (NPPD) perspectives on the significance of the findings, the bases for our position, our position on the basis for the apparent violations, and a discussion of the known differences between our assessment of the significance of these findings relative to the NRC evaluation.

NPPD expects to discuss this information with the NRC during a Regulatory Conference currently scheduled for March 29, 2001 (Reference 2). NPPD appreciates the opportunity to discuss the preliminary finding prior to the NRC's final determination of significance.

Enclosed as supporting documentation for the NPPD positions are three reports prepared by NPPD addressing both safety relief valve (SRV) operability and risk perspectives. These are: (1) a "White Paper for SRV Past Operability," (2) PSA-ES054, "Risk Evaluation Non-Conforming EQ Leads on PS-300 Switches," and (3) PSA-ES051, "Risk Assessment for EQ Concerns in the Drywell, Steam Tunnel and Reactor Building that led to FO 00-02."

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Should you have any questions concerning this matter, please contact Michael Boyce of the CNS Nuclear Licensing and Safety Department at (402) 825-5100.

Sincerely,

John H. Swailes
Vice President of Nuclear Energy

/erg
Attachment and Enclosures

cc: Regional Administrator w/attachment and enclosures
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EVALUATION OF PRELIMINARY FINDING
IDENTIFIED IN NRC INSPECTION REPORT NO. 00-07
COOPER NUCLEAR STATION
NRC DOCKET NO. 50-298, LICENSE DPR-46

Inspection Report Summary

During Nuclear Regulatory Commission (NRC) inspection activities conducted from April 19 through December 14, 2000, several findings were identified, including apparent violations of 10CFR 50.49, and 10CFR Part 50, Appendix B, Criterion III and Criterion XVI.

The Summary of Findings from NRC Inspection Report (IR) 00-07 are repeated below:

> "TBD. The inspectors identified multiple programmatic deficiencies involving the design, implementation, and documentation of environmental qualification applications. The programmatic deficiencies resulted in the existence of approximately 2000 applications affecting approximately 600 components important to safety. Although many accident mitigation scenarios may have been affected, the Significance Determination Process focused on the medium-break loss-of-coolant-accident (LOCA) scenario. The NRC concluded that the lack of proper environmental qualification treatments for the safety relief valve tailpipe pressure switches would have resulted in an inability of the valves to perform their depressurization function. The loss of the depressurization function would result in only one train retaining the capability of high pressure coolant injection. As a result, the NRC concluded that, for this scenario, the reduced capability for mitigation of a medium-break LOCA resulted in substantial safety significance."

> "TBD. The failures to environmentally qualify, maintain the qualification of, and document qualifications in an auditable form, for equipment important to safety, constituted an apparent violation of 10CFR 50.49."

> "TBD. Plant personnel failed to identify problems with the environmental qualifications program until they were specifically characterized by the NRC. Plant personnel also failed to identify problems with equipment that did not meet program requirements during field walkdowns. In addition, plant personnel failed to enter self-identified deficiencies, in the environmental qualifications program, into the corrective action program. These failures to properly identify problems and enter them into the corrective actions process constituted an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI."

> "TBD. The failures to ensure that environmentally qualified components had condensate drain measures described in design drawings, to properly test the containment spray valves, and to account for the effect of nonessential 125 Vdc loads on the operability of essential equipment during design basis accidents, were an apparent violation of 10CFR Part 50, Appendix B, Criterion III."

The Inspection Report indicates that the findings were assessed using the Significance Determination Process in NRC Inspection Manual Chapter 0609 and were preliminarily determined to be yellow, i.e., an issue of substantial importance to safety.

The nonconforming environmental qualification (EQ) treatments primarily consisted of tape splices both inside and outside the drywell that were either not installed in accordance with the tested configuration or degraded (e.g., outer tape unravelled). In addition, certain terminal blocks installed in the drywell were determined to not have been qualified for the peak drywell temperatures of a small break LOCA. Several months after these nonconformances were corrected, the safety relief valve (SRV) tailpipe pressure switches were discovered to be installed in a manner that did not match the tested configuration in the qualification test report. Finally, it was determined that nonessential indicating lights for the inboard drywell personnel airlock door (powered from essential 125 VDC) were not initially considered during investigation of the impact of the nonconforming SRV tailpipe pressure switches.

The key element in the NRC determination of finding significance is the assumption of loss of the depressurization function of the SRVs for certain postulated accident situations. The assumed inability of the SRVs to perform their depressurization function would significantly reduce the capability for mitigation of the small to medium break LOCA. The availability of the SRV function both deterministically and probabilistically has been evaluated by the Nebraska Public Power District (NPPD) and is the primary technical focus of the evaluation below. NPPD's evaluation of the summary of findings, the results of technical evaluations with a comparison to NRC analysis to provide a perspective on the significance of the findings, and some overall considerations relative to Inspection Report observations, are provided below.

Evaluation of the Summary of Findings

With regard to the first item identified in the NRC summary of findings, NPPD agrees that there were a large number of nonconforming EQ treatments restored to conformance by modification or replacement. Through application of the Corrective Action Program, NPPD has determined the root cause for these nonconformances and is aggressively pursuing resolution.

A number of conservative and prudent decisions were made in the spring outage to assure the timely restart of the unit. Upon our initial identification of the splice issue, NPPD commenced a review to determine the scope of nonconforming EQ configurations. As the scope expanded, the effort focused on identification of qualified replacements, without consideration of the qualifiability of the nonconforming EQ treatments. Indeed, many of the modified and replaced component configurations could have been further evaluated and/or tested and possibly qualified "as-is." However, NPPD chose to replace the majority of nonconforming EQ treatments rather than evaluate and pursue their qualification. In addition, as noted in the Inspection Report, splices were also replaced in some mild environment areas that did not require qualification. Because of this, it may not be appropriate to presume all the replaced splices had an impact on the safety of the plant.

For purposes of conservatively evaluating the risk imposed by these nonconforming EQ treatments, NPPD has assumed, for the most part, that affected equipment was not available in our probabilistic assessment discussed further below. Further, not all the nonconforming splices support equipment that is required to function for accidents which create a harsh environment; and only a few of the nonconformances are affected by any specific scenario. Again, NPPD did not seek to employ such perspectives to demonstrate qualification but, rather, promptly replaced the nonconforming EQ treatments. Individual evaluations of the limiting scenarios were also performed. A part of the evaluation included specific reviews to determine reasonable assurance of the capability of the SRVs to perform their required safety function of primary system depressurization. These and other elements of the NPPD evaluations demonstrate reasonable assurance of safe plant operation as discussed further below.

With regard to the NRC summary of findings constituting apparent violations of 10CFR 50.49, 10CFR Part 50, Appendix B, Criterion III, and 10CFR Part 50, Appendix B, Criterion XVI, NPPD generally agrees with the basis for the apparent violations with a few exceptions as described below. One specific area that requires clarification is the adequacy of the method employed to document and maintain auditable records of qualified splice configurations. 10CFR 50.49 (d) and (j) require that sufficient records must be available in an auditable form to permit verification that the covered item is qualified. NPPD maintains detailed documentation of acceptable splice qualification in EQ data packages that include specific information regarding acceptable configurations and post-accident environments for such treatments. However, the specific locations of individual commodities, such as splices are not records required by 10CFR 50.49. Consistent and longstanding industry practice distinguishes between such commodities and plant components. For example, individual component identification or tag numbers are rarely maintained for such commodities (which may include such items as splices, connectors, or gaskets). As noted in the Inspection Report, NPPD has met 10CFR 50.49 documentation requirements for splices by maintaining a set of approved configurations allowed in specific locations. Though not the most efficient practice for performing later investigations (should an approved configuration be identified as nonconforming), NPPD practice in this regard does not constitute a violation of 10CFR 50.49 documentation requirements.

Perspective on Significance of Findings, Bases, and Differences Relative to NRC Evaluation

NPPD has reviewed the summary of findings and generally agrees with the nature of these issues but not the preliminary NRC determination of their risk significance. Though significant in terms of licensing and design basis compliance, NPPD analyses indicate inherent design margins in key safety systems and components minimize the actual impact of the identified EQ nonconformances on risk for Cooper Nuclear Station (CNS).

NPPD performed a detailed analysis of the SRV control circuits and then evaluated the impact of the EQ nonconformances on the ability of the circuits to perform their required safety function (both deterministically and probabilistically). The results of the SRV circuits analysis and the risk analysis were made available for NRC evaluation. Because the risk analysis is significantly impacted by the capability of the SRVs to perform their depressurization safety function, the detailed circuits analysis was performed when SRV tailpipe pressure switch nonconformances were identified that may have impacted that SRV capability.

NPPD's Phase 3 risk analysis indicates there is sufficient inherent design margin such that, despite the identified EQ nonconformances, the condition was not risk significant.

Deterministic Analysis

The detailed analysis of the SRV control circuits conservatively considered leakage current effects due to the identified EQ nonconformances. The results of this evaluation concluded the circuits would be capable of performing their intended safety function despite the potential for faulted conditions in that the combined (bounding) effect of the leakage currents was within the capability of the installed circuit. While the analysis indicated that power for these SRV functions would not be affected, the SRV circuits are equipped with a power seeking feature that transfers control power to the alternate division should the circuit fuse open as a result of current faults. The alternate division contains significantly fewer circuit fault vulnerabilities due to its different circuit configuration. The results of this analysis were made available for NRC review. This analysis has also been subjected to independent reviews and, as noted, was recently revised to address comments from these independent reviews and from internal reviews. However, the revisions were of a clarifying nature and did not significantly revise the assumptions, methods, or results.

Because the 125 VDC circuit analysis is a key element of the risk determination, NPPD performed a Generic Letter 91-18 type "reasonable assurance" review of past operability of the SRVs considering concurrent conditions of nonconforming EQ treatments and nonconforming SRV tailpipe pressure switches. The analysis provided a comprehensive, conservative evaluation to assess the potential operability of the SRVs with the EQ nonconformances. Included in the conservatism applied to the analysis were concurrent, multiple, hypothetical adverse current paths, as well as assumptions of zero resistance faults (unless other faults were worst case), and bounding, continuous current values. The results of this conservative analysis provides reasonable assurance that the SRVs would have been capable of performing their safety function even under conservative, non-realistic assumptions.

The analysis results also demonstrate the inherent design margins provided by eight sets of fuses to power the SRVs (one set of two fuses for each SRV). An individual SRV is normally powered from the 125 V DC subsystem "A" through one 10 amp fuse. Backup power is provided from the 125 V DC subsystem "B" through a redundant 10 amp fuse. Each SRV circuit will automatically transfer to the 125 VDC subsystem "B" upon loss of power from the 125 VDC subsystem "A."

Specifically, the conservative analysis assumed multiple faults to occur simultaneously and the faults are assumed to be sustained, rather than intermittent as might be expected for random faults. The faults are assumed to impact only one SRV since concurrent impact of all eight SRVs would distribute total fault current among the eight SRV fuses. In this regard, the analysis found a maximum potential current through a single fuse of approximately 8.25 amps. Significantly, more realistic assumptions may include distribution of the current through multiple fuses reducing the current through any single fuse. For example, distribution of the current through all eight circuits fuses would produce a maximum current in any one fuse of approximately 2.3 amps. In addition, the analysis used worst case (e.g., zero resistance) faults for non-conforming EQ treatments and a transfer to the backup power division was not assumed because the current was not sufficient to impact the fuse in the primary power division. However, if power were to transfer from the "A" to the "B" DC subsystem, only the fault path from the associated pressure switch can transfer. Other parallel faults could not transfer and thus, the maximum resulting current for subsystem "B" would be only about 5.9 amps, which is significantly less than the maximum current postulated for subsystem "A."

Additional considerations included positive-side faults, fire potential, normal steady state current limitations, and common cause failure as a result of multiple faults. Other positive-side faults were considered in the SRV evaluation; however, such faults would not conservatively increase the current through the SRV fuses. Positive-side faults were also considered for the battery evaluation and determined to have no impact on the batteries. The fire potential is not considered plausible in a water and inerted nitrogen (drywell) environment. Also, the low currents through only one leakage path would not generate sufficient heat to initiate a fire. Due to circuit design, the normal steady state current is limited by the ground detection circuitry. Therefore, common cause failure as a result of multiple faults is not considered credible.

Potential interactions between AC Systems, 125 VDC Systems, 250 VDC Systems, and subsystems were also reviewed, and none were found either between systems or between divisions.

With regard to specific aspects of the circuit analysis described in NRC Inspection Report 00-07:

- The Inspection Report indicates additional uncertainties need to be applied in the SRV tailpipe pressure switch circuit failure analysis beyond the margins identified by NPPD (IR 00-07, page 11).

  NPPD has considered several areas of margin that constitute adequate consideration of uncertainty in the circuit failure analysis to provide reasonable assurance of the capability of the SRVs to perform their safety function. These include the margins available in 1) fuse ratings, 2) successful qualification testing on similar pressure switches, 3) required timing of the assumed faults, 4) the use of a zero ohm fault for cable resistance unless other faults were worst case, 5) the current magnitude assumed for the fault, 6) failure methods of the terminal blocks, and 7) the intermittent nature of leakage current. These margins were addressed in the SRV past operability evaluation (previously provided during the inspection) that concluded that the postulated condition would not likely cause the SRV circuit fuse to open. These margins, and the circuits analysis which indicated a potential current of less than the fuse rating, provide reasonable assurance that the SRVs would have been capable of performing their safety function.

In addition, NPPD had the evaluation reviewed by an independent engineering firm to identify any methods or assumptions that might be considered unjustified or non-conservative. The results of the review were incorporated without significant impact on the results or conclusions of the evaluation.

- The Inspection Report states (IR 00-07, page 11) that the licensee did not fully consider the effects of the multiple additional ground fault current flow paths that other nonconforming environmental qualification treatments might impose on the 125 VDC system.

  NPPD has considered the effects of the multiple additional fault current flow paths that nonconforming environmental qualification treatments might impose on the 125 VDC system for each division. The two divisions of 125 VDC are electrically and physically independent from each other and from the 250 VDC System and the AC System. The two divisions of 250 VDC are electrically and physically independent from each other and from the 125 VDC System and the AC System. The two divisions of AC are electrically and physically independent from each other and from both the 125 VDC System and the 250 VDC System. Nonessential loads powered from the essential 125 VDC system were also considered. No combinations of credible faults were identified that would result in propagation of failures between divisions or between these systems. The analysis continues to indicate that there is reasonable assurance the SRVs would have been capable of performing their safety function.

- The Inspection Report states (IR 00-07, page 12) that the licensee also assumed that no other negative leg ground existed, or would be created, on Division 2. The inspectors identified, however, that the faults caused by the SRV pressure switches would also cause current in excess of the 9.3 amps on Division 2.

  NPPD has considered the effects of the faults on Division 2. As indicated above, no faults were identified that would result in propagation of failures between divisions or between the power systems. As noted above, leakage current effects were also possible on the backup power supply for the SRVs but, due to the circuit configuration, to a much lesser extent, i.e., about 5.9 amps. The analysis continues to indicate that there is reasonable assurance the SRVs would have been capable of performing their safety function if such a divisional power transfer were to occur due to faults on Division 1.

Probabilistic Analysis

NPPD conducted a Phase 3 probabilistic safety assessment considering concurrent conditions of nonconforming EQ treatments and nonconforming SRV tailpipe pressure switches. The assessment was performed utilizing the results of the deterministic analysis which considered the SRVs operable. The assessment also considered the specific set of equipment needed for the specific set of events that contribute to risk. NPPD credited qualified equipment to operate at its normal assumed reliability. Nonconforming EQ treatments were only credited for performance, not qualification, when 1) the treatments were remote from the high energy line break (HELB) environment, 2) were known from inspection to not have any exposed metallics, and 3) when test data supports material performance. The NPPD results show both the core damage frequency (CDF) increase and the large early release frequency (LERF) increase to be below their respective GREEN to WHITE thresholds. Therefore, this assessment indicated that these conditions did not constitute a significant safety impact.

With regard to specific aspects of the probabilistic analysis described in Inspection Report 00-07:

- The NRC staff and risk analysts do not concur with many of the assumptions in the licensee's evaluation. (page 17)

  NPPD has had the evaluation reviewed by an independent engineering firm to identify any methods or assumptions that might be considered unjustified or non-conservative. The results of the review was incorporated (by revision) without significant impact on the results or conclusions of the evaluation. The revised risk evaluation is enclosed.

  An area where the NPPD assumptions may not conform to NRC expectations include the HELB initiating frequencies. NPPD frequencies were updated in accordance with EPRI-TR-102266 and are conservative when compared to NRC utilized NUREG/CR-5750.

Phase 2 Application

The NRC Phase 2 approximation was conducted in accordance with Manual Chapter 0609, Appendix A. The Inspection Report identifies the following steps and the associated findings.

- Select or Define the Applicable Initiating Event Scenarios:

  The inspectors determined that the primary concern with the degraded splice treatments was the potential current leakage, resulting in shorts, and/or grounds caused by a steam environment. Therefore, the applicable initiating event scenarios were limited to high energy line breaks. These included LOCAs and main steam or feedwater system line breaks in the drywell, reactor building, or steam tunnel.

NPPD generally agrees with this portion of the evaluation.

• Estimate the likelihood of scenario initiating events and conditions:

The inspectors assumed that the likelihood of an initiating event was not increased by the degraded conditions identified. Therefore, the inspectors used Significance Determination Process (SDP) Table 1 from Manual Chapter 0609, Appendix A. Based on the extended time that the degraded conditions had existed, all scenarios were evaluated using an exposure time of >30 days. Based on data gathered by evaluating multiple scenarios, the inspectors developed the assumption that the worst case event was the medium-break LOCA. SDP Table 1 provides the estimated likelihood of this event as 1 in every 1000 to 10,000 years. Therefore, the estimated likelihood rating was "D."

NPPD generally agrees with this portion of the evaluation as it applies to the bounding Phase 2 Significance Determination.

• Estimate the remaining mitigation capability:

The inspectors estimated the remaining mitigation capability in accordance with Step 2.3 of Manual Chapter 0609, Appendix A. In evaluating the medium-break LOCA, the inspectors assessed the equipment available to mitigate the event assuming that the 125 Vdc power to the SRVs had failed as described in Section 02.04 of this inspection report. The following assumptions were used:

- All SRVs fail to operate in relief mode based on the failure of their 125 Vdc power supply
- The SRVs are not recovered by operators
- High pressure coolant injection operates for 5 minutes despite degraded splice treatments for system components

Based on these assumptions, the inspectors evaluated the scenario using the "Medium LOCA" Phase 2 risk estimation worksheet provided in Risk Informed Inspection Notebook for Cooper Nuclear Station , Revision 0, September 20, 1999. The total remaining mitigation capability rating for Sequence 4 was determined to be 1 for one train of high pressure coolant injection.

As previously indicated above, NPPD evaluation does not support the assumed failure of the SRVs, and we therefore, generally do not agree with this portion of the evaluation.

• Estimate the risk significance of the inspection findings:

The inspectors estimated the risk significance of the inoperable SRVs using Table 2, "Risk Significance Estimation Matrix," of Manual Chapter 0609, Appendix A. According to the table, a likelihood rating of "D" and a remaining capability rating of 1 constitutes a YELLOW finding.

Because NPPD generally does not agree with the preceding portion of the evaluation, we also generally do not agree that the risk significance of the inspection findings constitute a YELLOW finding.

An NPPD application of the conditions to Table 2, "Risk Significance Estimation Matrix," of Manual Chapter 0609, Appendix A, results in a GREEN finding when the application utilizes the SRVs as available to perform their safety function.

Overall Considerations with Respect to the Inspection Report

NPPD has reviewed the preliminary finding, the apparent violations, and the sequence of events leading up to the issues as presented in the Inspection Report. Though not in agreement with the characterization of all the issues, NPPD considers them significant with respect to licensing and design base conformance. This was clearly evidenced by the number and magnitude of actions taken subsequent to the initial identification of EQ Program concerns. These actions resulted in an extended shutdown during which numerous electrical splices were evaluated and/or replaced, cause evaluations were performed in accordance with the site Corrective Action Program, and other program reviews were undertaken to bound the types of deficiencies identified in the EQ Program. NPPD continues to pursue resolution of these EQ issues. The EQ Program improvement project is proceeding to improve the CNS EQ Program, and assure that the program fully satisfies 10CFR 50.49. This improvement project is a station priority. However, the inherent margins in the station design, as applied to the specific accident conditions and the affected equipment, have led to the NPPD conclusion that this unique set of identified nonconformances constitute only a GREEN finding. This conclusion was reached through a Phase 3 probabilistic safety assessment. NPPD also acknowledges that other sets of affected equipment could have led to a different result.

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The following table identifies those actions committed to by the District in this document. Any other actions discussed in the submittal represent intended or planned actions by the District. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the NL&S Manager at Cooper Nuclear Station of any questions regarding this document or any associated regulatory commitments.

COMMITMENT	COMMITTED DATE OR OUTAGE
None	

ENCLOSURES

Enclosure 1
"White Paper for SRV Past Operability"
Revision 1

Enclosure 2
PSA-ES054, Revision 0
"Risk Evaluation Non-Conforming EQ Leads on PS-300 Switches"

Enclosure 3
PSA-ES051, Revision 3
"Risk Assessment for EQ Concerns in the Drywell,
Steam Tunnel and Reactor Building that led to FO 00-02"

NLS2001034
Enclosures

ENCLOSURE 1

"White Paper for SRV Past Operability"
Revision 1
18 Pages

White paper for SRV past operability

Revision #1

Purpose

The Operability Evaluation (OE) for PIR 4-11673, concluded that the SRVs would remain operable in a post LOCA environment provided no pre-existing fault to ground of the negative 125 VDC bus. The OE used conservative assumptions and determined a maximum of 9.13 amps would flow through the 10 amp SRV fuses.

A past operability question has been raised concerning the effects of this condition concurrent with the conditions found during the EQ outage and the presence of the personnel airlock indicating lights located in the drywell (which are currently tagged out to isolate them from the bus). While past operability has been addressed on each of these conditions individually, the synergistic effects of these items on the past operability of the SRVs and DC system are evaluated below.

The purpose of the white paper was to discuss the bounding affects of the failed SRV fuses, and not all of the discussions or evaluations that were considered were included. Since the completion of this white paper in November, additional questions have been identified. Specifically, the following items will be addressed in Revision #1.

1) The past operability of the 125VDC system was not addressed.
2) Interaction of the grounds on the 125 VDC system with the other DC and AC systems
3) The auto-transfer function of the SRV circuits
4) The impact of DC and AC on the same terminal blocks
5) The impact to resistance uncertainties in the ground fault analysis
6) The orientation non-conformance of Weidmuller terminal blocks.
7) Hypothetical fires as result of the ground faults
8) Adequate voltage to the SRV concurrent with the additional faults
9) How did we handle the permutations of interactions.

An addendum was generated (attachment 3) to this white paper to address the additional factors.

Evaluation

Scope

The issue with the SRV pressure switches is a result of a LOCA induced fault on the 125 VDC system. The scope of this evaluation will be the identified EQ non-conformances located in the drywell that is powered from the 125 VDC system.

The PIRs generated during RFO19 and the subsequent EQ outage were reviewed to identify the various EQ issues. These issues are: 1) The non-conformance of the PS-300A-H pressure switches; 2) the non-conforming Okonite tape splices; 3) non-conforming 3M tape splices; 4) non-conforming Raychem splices; 5) Buchanan 0241 terminal blocks; 6) the drywell personnel airlock indicating lights; 7) the Limitorque t-drains; and 8) the ground of the motor for RR-MO53A.

The methodology used in this evaluation determines the maximum current through the SRV 10-amp fuses. The effects of each non-conformances will be added to this amperage and compared against the manufacturers continuous fuse ratings of the SRV fuses.

Background

A list of electrical equipment located in the drywell that has circuits fed directly from the 125 VDC system was developed. A two-fold approach was used to develop this list.

1) The EDF was searched to identify a list of all applicable 125 VDC electrical SSC located in the drywell. This list is included as attachment 1.

2) The DC one-line drawings were reviewed to identify the SSC powered from the 125 VDC system. The elementary drawings for this equipment were reviewed to determine if any part of that circuit would communicate with drywell environment and if necessary it was added to attachment 1.

The cables with the 125 DC circuits for the above list of equipment were identified. The EQ walkdown database developed during the EQ outage, as well as the PIRs generated during the EQ outage was used to identify the EQ non-conformances. This list of the resulting non-conformances is included as attachment 2.

Based on attachment 2, the EQ issues located in the drywell are the non-conforming PS-300A-H pressure switches; 2) Non-conforming Okonite tape splices; 3) Non-conforming Raychem splices; 4) Buchanan 0241 terminal blocks; and 5) The drywell personnel airlock indicating lights (i.e., RR-MO53A motor is 250VDC, and the identified motor operator valves had t-drains).

OE for PIR 4-11673

The OE for PIR 4-11673 determined the impact of the non-conforming PS-300 pressure switches. Rather than determining if the devices were qualifiable, the OE conservatively assumed the device would fail in the worst case credible fashion, and performed an FMEA for each failure mode.

The OE identified that with a pre-existing fault on the negative bus below the detection level of the switchgear detection system (i.e., greater than 150 ohms), the maximum fault current created by a ground of the pressure switches is 1.13 amps. This assumes the pressure switches develop a bolted fault (i.e., zero ohms fault) to ground which is conservative (see Discussions of Margin).

The OE calculated the bounding amperage for the normal SRV circuit as 2.0 amps. This bounding assumption is overly conservative in that it assumed that every device in the circuit was energized (including the LLS logic that only impacts two of the SRVs), and then rounded up to make an even 2.0 amps. Using the system elementary drawings and NEDC 87-131C a maximum amperage of 1.401 amps is calculated.

The OE also included additional 6 amps of continuous current through the low resistance path of the RRMG breaker logic due to the fact that RR-MO43A/B is classified as non-essential and is located in the drywell. This is an overly conservative assumption since RR-MO43A/B are qualifiable Limitorque motor operators.

Based on the above, the impact of the non-conforming condition of the PS-300 pressure switches is that a maximum current of 2.531 amps (maximum ground fault of 1.13 amps, and maximum circuit current of 1.401 amps) would flow through each of the SRV 10 amp fuses.

The maximum current draw as a result of this fault is 1.13 amps. The limitation is the high resistance of the ground detection circuitry, and not the annunciation of the fault. If all of the SRVs faulted, the maximum current would be limited to 1.13 amps.

Therefore, to maximize the challenge to the SRV fuses in this evaluation, all of the fault will be concentrated in a single SRV.

Synergistic effects due to the as found condition of EQ outage

The following discussion addresses the credible faults of the negative bus of the 125 VDC system. Since additional grounds of the positive bus would actually decrease the current through the SRV 10-amp fuse only additional potential grounds to the negative bus need to be considered.

A review of attachment 1 & 2 identifies the following components with a non-conforming condition:

- MS-PS-256A-H
- RR-MO43A/B
- RR-MO53A/B
- MS-AO80A-D
- EE-RIL/GIL-EXTDOOR/VALVE

MS-PS-256A through H are the SRV accumulator pressure alarm switches. Indication power is supplied from AA2 (circuit #5 via 5-amp fuses F101/F102) to the Control Room indicating lights. The maximum challenge to the SRV 10-amp fuse is from an unlikely combination of a simultaneous ground fault on the lamp side of all of the PS-256A-H pressure switches (with the contacts open), and a fault on the positive side of an open PS-300A-H. This combination would illuminate all of the accumulator lights and corresponding annunciator relays (ANN-REL-PS256A-HX). Per NEDC 817131C each indicating light draws 46 mA while each relay draws 12mA. This adds an additional 0.464 amps to the 2.531 amps calculated above for a total of 2.995 amps.

RR-MO43A and RR-MO43B are Limitorque motor operators. The 125 VDC system uses spare contacts on the 480 VAC Limitorque actuators for the RRMG set breaker logic. The configuration of RR-MO43A/B uses a total of four spare contacts in both the open and close circuit of the RRMG set breaker to the normal transformer (1CN/1DN) and the RRMG set breaker to the startup transformer (1CS/1DS).

The RRMG sets are configured such that one is powered from the normal transformer (i.e., 1CN or 1DN breaker is closed) and other is powered from the startup transformer (i.e., 1CS or 1DS is closed).

The internal breaker actuating switches electrically isolate the trip coil of a open breaker, and the close coil of a closed breaker from the drywell portion of the circuits..

As stated in the OE, the small or medium size LOCA that creates a harsh environment would pressurize the drywell to the 2-pound scram setpoint prior to creating any fault current from the pressure switches. This high drywell pressure signal initiates a secondary containment isolation valve closure, which trips the RRMG ventilation fans. The RRMG fan de-energization electrically isolates the breaker close coil from the drywell portion of the circuit.

Per NEDC 87-131C and NEDC 87-131D the trip coils amperage is 6 amps. However, 6 amps would cause the breaker to actuate and cause the breaker actuating switches to electrically isolate the drywell portion of the circuit. This breaker actuation occurs in less than 50 milliseconds, without challenging the clearing time of the SRV fuses.

A bounding continuous amperage of the circuit breakers would be the amperage of the trip coil energized to less than the minimum operating voltage. Per NEDC 97-131C and 87-131D, the minimum operating voltage of the trip coils is 70 volts and the nominal rating is 125 volts. The adding of a continuous 3.36 amps (i.e., 6*70/125) to the above calculated 2.995 amps results in a total of 6.355 amps.

RR-MO53A and RR-MO53B are Limitorque motor operators. Similar to RR-MO43A/B the 125 VDC system uses spare contacts on the 250 VDC Limitorque actuators for the RRMG set breaker logic. These contacts in the trip circuits are in parallel to the contacts of RR-MO43A/B and do not provide any additional fault current. However, the contacts in the close circuits also provide control of relay K55A/B.

Credible fault conditions include the simultaneous ground fault on the K55A/B relay side of the limit switch with the limit switch contacts open. This combination would energize the relay from the fault of the PS-300A-H. Per NEDC 81-131C/D the relay amperage is 32 mA, which added to the 6.355 amps calculated above results in a total of 6.387 amps.

MS-AO80A through D are the inboard Main Steam Isolation Valves. Included as part of these devices are 2 AC powered solenoid valves and one 125 VDC powered solenoid valve on each valve. All four of the inboard DC powered solenoid valves are powered from the Division I 125 VDC system. A 5-amp fuse (type MIN) protects all four MSIV solenoid valves, while a 10-amp fuse (also type MIN) protects each SRVs.

Two fault conditions are evaluated to bound the as-found conditions: 1) a fault of one or more negative leads of the 125 VDC solenoid coil coincident with the faults discussed above; and 2) a fault of all four positive leads of the 125 VDC solenoid valve with the contacts to the solenoid valve open.

The first fault condition results in a direct short from the positive to negative bus. Current would flow through the SRV 10 amp positive fuse, through the ground, and through the 5-amp MSIV negative fuse. Coordination exists to ensure that the fault would be cleared by the MSIV 5-amp fuse due to the different fuse melting characteristics of the fuses. Therefore, this condition would not increase the above calculated amperage value and the SRVs would continue to operate as discussed in the OE.

The second fault condition would result in the energizing of the solenoid valves from the PS-300A-H pressure switches. Per NEDC 81-131C/D each solenoid valve has an amperage rating of 139 mA, which added to the 6.387 amps calculated above, results in a total of 6.943 amps.

EE-RIL/GIL-EXTDOOR/VALVE are the drywell personnel airlock indicating lights located inside of the drywell that are powered from the 125 VDC system (division I).

The lights are standard indicating lights located in what is conservatively assumed to be a non-sealed type box (sealed box would preclude any possibility of shorting). A similar configuration of standard indicating lights in a non-sealed enclosure were successfully tested as documented in EQDP 230.

A lens cover protects the electrical connections and bulbs. This cover would have to melt to allow a surface film of moisture to accumulate to provide the conduction path to ground. Assuming this would happen, the surface conduction path would be over the irregular shaped light socket, to the surface of the protection box. This irregular shape helps to minimize any pooling of water on the surface and tends to cause drip points to drain moisture away. In addition, the lights are approximately 6 feet off of the drywell 901 level, which precludes them from becoming submerged.

The light socket is a phenolic type material, which has been successfully tested using the IEEE generic profile of 340°F for several hours (unlike the nylon Buchanan terminal blocks).

The configuration of open terminals separated by an irregular shaped insulator is similar to the numerous EQ tests performed on terminal blocks. NUREG CR-3691 is the documentation of a generic terminal block testing program performed by Sandia Labs.

This NRC sponsored generic terminal block test report states:

> "Surface leakage currents are the primary mechanism by which terminal blocks contribute to I&C circuit degradation"

Terminal block construction is such that the surface conduction path is typically much shorter in a terminal block than the light socket. Therefore it is reasonable to use this testing to qualitatively determine the performance of the light switches.

Note this type of failure mode is not conducive of a sustained fault of several amps, as this amount of current through such a thin surface film tends to evaporate the water and thus self-limits the maximum fault current.

The Sandia report also states

> "During Sandia's test of terminal blocks in a simulated LOCA environment, insulation resistance at 4 VDC, 45 VDC and 125 VDC fell to 10^2 to 10^4 ohms from initial values of 10^8 to 10^{10} ohms."

Calculating a maximum fault current using the bottom of this range would be less than 1.305 amps (i.e., the maximum float voltage divided by 100 ohms). The addition of this current to above calculated 6.943 amps, results in a total current draw of 8.248 amps.

Discussion of Margin

This evaluation assumes a fuse rating of 10-amps and all of the various configurations would result in a bolted fault (i.e., zero ohms) to ground. The following discusses the conservatism of the evaluation.

1) The SRV fuse is a UL listed fuse that can support 110% of its rating indefinitely. The manufacture ratings (as well as the UL listing) for the MIN fuses meet this requirement.

2) Since the scenario of concern is a small or medium break LOCA, the SRV operation would occur within the first hour of the accident. The 10-amp SRV fuses can support continuous amperage of 11 amps, and 13.5 amps for a period of one hour based on the manufacturer ratings.

3) A qualifiability argument could be made made for the pressure switches based on successful type testing performed by GE without conduit seals. Although that test used a switch with a different type of lead wire, generic EQ testing of wiring and cable demonstrates that when wiring fails, the insulation resistance does not drop to zero. Typical insulation resistances are greater than 1000 ohms/ foot. If an unlikely failure of cable insulation resistance degraded to an insulation resistance of 100 ohms the fault current would be reduced by a factor of two. Similarly, an insulation resistance of 1000 ohms would drop the fault current by at least a factor of ten.

   In addition, the above analysis assumes the pressure switches develop an instantaneous fault to ground. In reality, the pressure switches are located inside of an enclosure that provides a tortuous path for moisture to enter to the switches. This provides additional protection for the switches. It is unlikely the switches would see significant moisture from the accident prior to the requirement for the switches to function.

4) In all of the faults, a zero ohm fault was assumed for cable resistance to bound conditions for determination of the impacts to the battery and the SRV fuses.

When examining all of the EQ non-conformances, no bare wires with the cable laying directly on metal enclosures were found. Therefore, the conduction path to ground is due to surface moisture conduction, which would not result in a bolted fault condition.

5) The as-found configuration of the various splices provided an additional tortuous path for leakage current to ground. While the configurations could have resulted in leakage current to ground could have been significant for instrumentation applications (e.g., 4-20 mA loops); the amount of current assumed in this evaluation is unrealistic.

6) Although the Buchanan 0241 terminal block is EQ qualified, they were not tested to the higher temperatures possible during a small break LOCA. The major concern of these blocks is the potential melting of the nylon blocks. The above analysis used the worst case assumption of preferential melting of select terminals completely to ground without disturbing the adjacent terminal. Any other failure scenario would not result in the maximum fault currents discussed above. In addition to the obvious conservative nature of the assumed preferential melting, all of the terminal blocks were assumed to develop a bolted fault, which is discussed in #4 above.

7) Although the analysis assumes that the drywell indicating lights have a continuous fault current of 1.5 amps, the Sandia report discusses the intermittent nature of leakage current at these high levels. This is due to the fact that the leakage current is a result of surface film conduction, and high currents have a tendency to evaporate this surface film. This coupled with the fact that the results discussed in the Sandia test were from terminal blocks with a much shorter surface conduction path (i.e., terminal to terminal), indicate that a more realistic conservative assumption would to use the mid range of 10^2 to 10^4 ohms. A resistance a 5000 ohms would drop the 1.305 amps of assumed fault current to 0.026 amps

Conclusion

This evaluation delineates the conservatism in the methodology presented in the OE for PIR 4-11673 and has demonstrated past operability of the 10-amp SRV control power fuses. This evaluation calculated an conservative condition which would result in the SRV 10-amp fuse being subjected to a bounding continuous current amperage draw **of 8.248 amps which is well below the nominal 10-amp rating.**

In addition to the margin already included in the calculated 8.248 amps, a 133% margin exists to the continuous rating of the fuse.

3-21-01
Originator

3-21-01
EQ Review

3-22-01
DED Electrical Review

3/21/01
Engineering Supervisor

Attachment 1 – List of 125 VDC equipment in drywell
Attachment 2 – EQ Outage as-found configuration of drywell equipment
Attachment 3 – Addendum 1

Div	Class	CIC	Desc	Drawing	Location	Power Feed
I	E	MS-PS-256A	RV ACC 256A LO PRESS ALM	3048	DW-921 (NE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256B	RV ACC 256B LO PRESS ALM	3048	DW-921 (NE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256C	RV ACC 256C LO PRESS ALM	3048	DW-921 (NE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256D	RV ACC 256D LO PRESS ALM	3048	DW-921 (NE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256E	RV ACC 256E LO PRESS ALM	3048	DW-921 (SE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256F	RV ACC 256F LO PRESS ALM	3048	DW-921 (NE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256G	RV ACC 256G LO PRESS ALM	3048	DW-921 (SE)	AA2(5)(16A-F101&F102
I	E	MS-PS-256H	RV ACC 256H LO PRESS ALM	3048	DW-921 (SE)	AA2(5)(16A-F101&F102
I	EQ	RR-MO-MO53A*	RR P A DISCH	3018, 3071, 0223R0558 SHEETS 26 & 28	DW-888 (SW)	AA1(4)(1CN-NR&NQ, 1CS-NR&NQ)
I	EQ	MS-AO-AO80A	MS ISO V A INBOARD	791E266 SHEETS 4 & 10	DW-921 (E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-AO-AO80B	MS ISO V B-INBOARD	791E266 SHEETS 4 & 10	DW-921 (E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-AO-AO80C	MS ISO V C INBOARD	791E266 SHEETS 4 & 10	DW-921 (E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-AO-AO80D	MS ISO V D INBOARD	791E266 SHEETS 4 & 10	DW-921 (E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80A(A)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80A(A)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80A(F)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80A(F)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80B(A)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80B(A)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80B(F)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80B(F)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80C(A)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80C(A)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80C(F)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80C(F)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80D(A)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80D(A)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-CSA-AO80D(F)	ELEC CONDR SEAL ASSY F/ MS-LMS-AO80D(F)	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80A(A)	OPEN LMS ON MSIV 80A	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80A(F)	CL LMS ON MSIV 80A	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80B(A)	OPEN LMS ON MSIV80B	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80B(F)	CL LMS ON MSIV80B	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80C(A)	OPEN LMS ON MSIV80C	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80C(F)	CL LMS ON MSIV80C	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80D(A)	OPEN LMS ON MSIV80D	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	EQ	MS-LMS-AO80D(F)	CL LMS ON MSIV80B	791E266 SHEETS 4 & 10	DW-901(E)	AA2(12)(16A-F10A&F11A)
I	N	RR-MO-MO43A*	RR P A SUCT	3018, 0223R0558 SH 26&28, 730E197BB SH 7	DW-888 (SW)	AA1(4)(1CN-NR&NQ, 1CS-NR&NQ)
I	NA	EE-R/GIL-EXTDOOR/VALVE**	DW AIRLOCK INDICATING LIGHTS	3045	DW-901 (W)	AA3(5)
I & II	EQ	MS-PS-300A	RV-71A DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (N)	AA2(15) (2E-F3A&F4A)(NORM);BB2(8)(2E-F11A&F12A)(ALT)
I & II	EQ	MS-SOV-SPV71A	PILOT V F/ MS-RV-71ARV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15) (2E-F3A&F4A)(NORM);BB2(8)(2E-F11A&F12A)(ALT)
I & II	EQ	MS-PS-300B	RV-71B DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (NE)	AA2(15)(2E-F3B&F4B)(NORM);BB2(8)(2E-F11B&F12B)(ALT)
I & II	EQ	MS-SOV-SPV71B	PILOT V F/ MS-RV-71BRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3B&F4B)(NORM);BB2(8)(2E-F11B&F12B)(ALT)
I & II	EQ	MS-PS-300C	RV-71C DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (NE)	AA2(15)(2E-F3C&F4C)(NORM);BB2(8)(2E-F11C&F12C)(ALT)
I & II	EQ	MS-SOV-SPV71C	PILOT V F/ MSRV-71CRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3C&F4C)(NORM);BB2(8)(2E-F11C&F12C)(ALT)
I & II	EQ	MS-PS-300D	RV-71D DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (NE)	AA2(15)(2E-F3D&F4D)(NORM);BB2(8)(2E-F11D&F12D)(ALT)
I & II	EQ	MS-SOV-SPV71D	PILOT V F/ MSRV-71DRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3D&F4D)(NORM);BB2(8)(2E-F11D&F12D)(ALT)
I & II	EQ	MS-PS-300E	RV-71E DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (SE)	AA2(15)(2E-F3E&F4E)(NORM);BB2(8)(2E-F11E&F12E)(ALT)
I & II	EQ	MS-SOV-SPV71E	PILOT V F/ MS-RV-71ERV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3E&F4E)(NORM);BB2(8)(2E-F11E&F12E)(ALT)
I & II	EQ	MS-PS-300F	RV-71F DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (SE)	AA2(15)(2E-F3F&F4F)(NORM);BB2(8)(2E-F11F&F12F)(ALT)
I & II	EQ	MS-SOV-SPV71F	PILOT V F/ MS-RV-71FRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3F&F4F)(NORM);BB2(8)(2E-F11F&F12F)(ALT)
I & II	EQ	MS-PS-300G	RV-71G DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (SE)	AA2(15)(2E-F3G&F4G)(NORM);BB2(8)(2E-F11G&F12G)(ALT)
I & II	EQ	MS-SOV-SPV71G	PILOT V F/ MSRV-71GRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3G&F4G)(NORM);BB2(8)(2E-F11G&F12G)(ALT)
I & II	EQ	MS-PS-300H	RV-71H DISCH PRESS MONITOR	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (SE)	AA2(15)(2E-F3H&F4H)(NORM);BB2(8)(2E-F11H&F12H)(ALT)
I & II	EQ	MS-SOV-SPV71H	PILOT V F/ MSRV-71HRV	944E689, 791E253 SHEETS 1, 2, & 3	DW-921 (E)	AA2(15)(2E-F3H&F4H)(NORM);BB2(8)(2E-F11H&F12H)(ALT)
I & II	EQ	RHR-MO-MO18*	RHR SD COOL SUPPLY INBOARD ISO	791E261 SH 4,7,&12, 791E266 SH 2&12	DW-901 (W)	AA2(6)(10A-F1A&F2A);BB2(8)(10A-F1B&F2B)
II	EQ	RR-MO-MO53B*	RR P B DISCH	3018, 3071, 0223R0558 SHEETS 29 & 30	DW-888 (NE)	BB1(2)(1DN-NR&NQ, 1DS-NR&NQ)
II	N	RR-MO-MO43B*	RR P B SUCT	3018, 0223R0558 SH 29&30, 730E197BB SH 7	DW-888 (NE)	BB1(2)(1DN-NR&NQ, 1DS-NR&NQ)

* Not powered from 125VDC, but has 125VDC auxiliary circuit
** Not a real CIC

CIC	Impact	Cable	T Box	As Found Configuration
MS-PS-256A	Assume worst case faults in addition to those assumed in OE	CS161	131	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS160	131	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256B	Assume worst case faults in addition to those assumed in OE	CS162	131	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS160	131	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256C	Assume worst case faults in addition to those assumed in OE	CS163	131	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS160	131	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256D	Assume worst case faults in addition to those assumed in OE	CS159Z	131	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS160	131	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256E	Assume worst case faults in addition to those assumed in OE	CS165	133	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS164	133	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256F	Assume worst case faults in addition to those assumed in OE	CS158Z	133	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS164	133	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256G	Assume worst case faults in addition to those assumed in OE	CS166	133	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS164	133	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-256H	Assume worst case faults in addition to those assumed in OE	CS167	133	No documented inspection, drawings state Buchanon 0241 terminal block.
		CS164	133	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
MS-PS-300A	NONE	CS171	179	Qualified Weidmuller Terminal Block
		CS171'	179	Qualified Weidmuller Terminal Block
			145	Qualified Weidmuller Terminal Block
		CS111	145	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration

MS-PS-300B	NONE	CS172	179	Qualified Weidmuller Terminal Block
		CS172'	179	Qualified Weidmuller Terminal Block
			147	Qualified Weidmuller Terminal Block
		CS111	147	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-PS-300C	NONE	CS173	179	Qualified Weidmuller Terminal Block
		CS173'	179	Qualified Weidmuller Terminal Block
			149	Qualified Weidmuller Terminal Block
		CS113	149	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-PS-300D	NONE	CS174	179	Qualified Weidmuller Terminal Block
		CS174'	179	Qualified Weidmuller Terminal Block
			151	Qualified Weidmuller Terminal Block
		CS114	151	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-PS-300E	NONE	CS175	161	Qualified Weidmuller Terminal Block
		CS175'	161	Qualified Weidmuller Terminal Block
			153	Qualified Weidmuller Terminal Block
		CS115Z	153	Qualified Weidmuller Terminal Block
			X100G	Qualified Raychem configuration
MS-PS-300F	NONE	CS176	161	Qualified Weidmuller Terminal Block
		CS176'	161	Qualified Weidmuller Terminal Block
			155	Qualified Weidmuller Terminal Block
		CS116Z	155	Qualified Weidmuller Terminal Block
			X100G	Qualified Raychem configuration
MS-PS-300G	NONE	CS177	161	Qualified Weidmuller Terminal Block
		CS177'	161	Qualified Weidmuller Terminal Block
			157	Qualified Weidmuller Terminal Block
		CS117Z	157	Qualified Weidmuller Terminal Block
			X100G	Qualified Raychem configuration
MS-PS-300H	NONE	CS178	161	Qualified Weidmuller Terminal Block
		CS178'	161	Qualified Weidmuller Terminal Block
			159	Qualified Weidmuller Terminal Block
		CS118Z	159	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71A	NONE	CS137	145	Qualified Weidmuller Terminal Block
		CS111	145	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration (replaced but later evaluated as acceptable).

MS-SOV-71B	NONE	CS138	147	Qualified Weidmuller Terminal Block
		CS112	1147	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration (replaced but later evaluated as acceptable).
MS-SOV-71C	NONE	CS139	149	Qualified Weidmuller Terminal Block
		CS113	149	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71D	NONE	CS140	151	Qualified Weidmuller Terminal Block
		CS114	151	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71E	NONE	CS141	153	Qualified Weidmuller Terminal Block
		CS115Z	153	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71F	NONE	CS142	155	Qualified Weidmuller Terminal Block
		CS116Z	155	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71G	NONE	CS143	157	Qualified Weidmuller Terminal Block
		CS117Z	157	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
MS-SOV-71H	NONE	CS167	133	Qualified Weidmuller Terminal Block
		CS164	133	Qualified Weidmuller Terminal Block
			X100A	Qualified Raychem configuration
RR-MO-MO43A	Assume worst case faults in addition to those assumed in OE	H256	101	No documented inspection, drawings state Buchanon 0241 terminal block.
		H254	101	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
		H253	101	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
RR-MO-MO43B	Assume worst case faults in addition to those assumed in OE	H296	102	No documented inspection, drawings state Buchanon 0241 terminal block.
		H294	102	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100G	No documented inspection of internal penetration. Will assume non-qualified Tape Splice.
		H293	102	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100G	No documented inspection of internal penetration. Will assume non-qualified Tape Splice.

RR-MO-MO53A	Assume worst case faults in addition to those assumed in OE	H257	101	No documented inspection, drawings state Buchanon 0241 terminal block.
		H254	101	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
		H253	101	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100A	No documented inspection of internal penetration, pictures show mostly Raychem, outside had tape splice. Will assume non-qualified Tape Splice.
RR-MO-MO53B	Assume worst case faults in addition to those assumed in OE	H297	102	No documented inspection, drawings state Buchanon 0241 terminal block.
		H294	102	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100G	No documented inspection, drawings state Buchanon 0241 terminal block.
		H293	102	No documented inspection, drawings state Buchanon 0241 terminal block.
			X100G	No documented inspection of internal penetration. Will assume non-qualified Tape Splice.
RHR-MO-MO18	NONE	MR12	X102	Qualified Raychem configuration
MS-AO-AO80A	Assume worst case faults in addition to those assumed in OE	PC149	103	Buchanon 0241 terminal block
			X100A	Non-qualified tape splice
MS-AO-AO80B	Assume worst case faults in addition to those assumed in OE	PC155	107	Buchanon 0241 terminal block
			X100A	Non-qualified tape splice
MS-AO-AO80C	Assume worst case faults in addition to those assumed in OE	PC161	111	Buchanon 0241 terminal block
			X100A	Non-qualified tape splice
MS-AO-AO80D	Assume worst case faults in addition to those assumed in OE	PC169	115	Buchanon 0241 terminal block
			X100A	Non-qualified tape splice
MS-LMS-AO80A(A) & (F)[1]	NONE	PC150	105	Buchanon 0241 terminal block
			X100A	Qualified Raychem configuration
MS-LMS-AO80B(A) & (F)[1]	NONE	PC156	107	Buchanon 0241 terminal block
			X100A	Qualified Raychem configuration
MS-LMS-AO80C(A) & (F)[1]	NONE	PC162	113	Buchanon 0241 terminal block
			X100A	Qualified Raychem configuration
MS-LMS-AO80D(A) & (F)[1]	NONE	PC170	117	Buchanon 0241 terminal block
			X100A	Qualified Raychem configuration

Note 1: The conduit seal assemblies (i.e., MS-CSA-AO80…) are included in the limit switch evaluation (i.e., MS-LMS-AO80…)
Note 2: All interfacing circuits of EE-R/GIL-EXTDOOR/VALVE are external of the drywell

White paper for SRV past operability

Addendum

Purpose

The purpose of this addendum is to address specific questions concerning the original white paper and assess if it remains a bounding analysis.

Specifically, the additional questions/non-conformances are:

1) The impact on the 125 VDC system was not discussed.
2) Interactions of the grounds on the 125 VDC system with the other DC and AC systems.
3) The auto-transfer function of the SRV circuits.
4) The impact of DC and AC circuits on the same terminal blocks.
5) The impact of resistance uncertainties in the ground fault analysis.
6) The orientation non-conformance of Weidmuller terminal blocks.
7) Hypothetical Fire that may occur as a result of the faults and disable the SRVs
8) Adequate voltage to SRV with additional faults
9) How can we make sure that we have covered all of the permutations of interactions

This addendum will evaluate the impact of these additional factors.

Evaluation

The following information is provided for calrification:

1) Impact to the 125VDC System

A question was raised concerning the impact to the 125VDC system. However, the loads discussed in the white paper are already evaluated in NEDC 87-131C and NEDC 87-131D. These calculations are the DC load study for the 125VDC "A" and "B" system respectively.

The 125 VDC system is an ungrounded system, the maximum ground fault current for one, two or any number of zero resistance ground faults is 1.13 amps (NEDC 91-197). This conservative amperage assumes a PRE-EXISTING, co-incident, DETECTABLE fault on the NEGATIVE bus. Review of the material history indicates this pre-existing ground fault of the 125 VDC system has not occurred over the past three years. Without this additional pre-existing fault on the negative bus, the total fault current would be a maximum of only 0.25 amps (NEDC 91-197).

The white paper concentrated this entire ground fault through a single fuse. If there were multiple faults, the 1.13 amps would be divided among the various faults. However, the maximum fault current would remain as 1.13 amps whether there was one, two or any number of zero resistance ground faults. This maximum ground fault current has been included in the DC load study calculations. Also, the SRV circuit loads have already been factored into the load study and the normal loads discussed in the white paper do not represent any new loads beyond those already analyzed.

Therefore, the ground faults discussed in the white paper have already been factored into the load study.

However, the load study assumes the MSIVs are closed (de-energized), so the additional loads for the smart faults (i.e., faults assumed in the white paper to travel from a non-conforming component to ground, through the ground path to another non-conforming component) provide leakage current to the MSIVs need to be considered. In the same fashion, the drywell indicating lights, the RRMG set breakers, and the MS-

PS-256A-H relays are additional loads to be considered. From the white paper, these additional loads are less than 6 amps.

The peak calculated load for the 125 VDC "A" battery is 317 amps and occurs within the 2 to 4 second time frame (NEDC 87-131C). It then drops to less than 239 amps. The ADS is locked out for a minimum of 2 minutes, which precludes the actuation occurring simultaneous with this peak. Although SRV actuation would not occur concurrent with the calculated peak, the additional currents from the smart faults represents less than 2% of this maximum current.

NEDC 87-131C is the Division I 125 VDC load and voltage study. Its purpose is to determine loading on the 125 A battery and to show that adequate voltage is available to all Division I safety related components such that they can perform their safety function. That calculation assumes the battery is at 80 percent capacity while factory and battery performance tests show the battery capacity is at least 90 percent (actual results show closer to 100 percent, 90 percent is a conservative value for this evaluation). Since the increase in load to the faults considered herein represent less than 2% of the peak battery load, the calculations show that adequate margin is available, both with respect to voltage and capacity, that these extra loads do not impact the batteries ability to perform its safety function.

Additionally, battery service test are conducted with a minimum of 2% margin above the calculated profile. The battery service tests are conducted once per cycle.

Therefore the additional loads from the various EQ non-conformances do not deleteriously impact 125 VDC battery and the results of the white paper are not affected.

2) Ground Interaction between the 125 VDC, the 250 VDC, and AC systems

The 125 VDC system is composed of two physically and electrically independent batteries, switchgear, and electrical distribution system. In that same fashion, the 250 VDC system is composed of two physically and electrically independent batteries, switchgear, and electrical distribution systems. The 125 and the 250 volt battery systems are also electrically and physically separate batteries, switchgear, and electrical distribution system. In other words, the 125 and 250 VDC systems are four SEPARATE batteries, switchgear, and electrical distribution system. These systems are all ungrounded systems, and are therefore completely independent from each other.

Similarly, the AC system is composed of physically and electrical independent switchger, transformer and distribution systems. The battery chargers have sufficient isolation to assure that no interaction occurs between the AC and the DC system.

Since all electrical current must form a completed path, the independence assures that no common current paths exist. At the most basic level, an electron from the 125 VDC "A" battery must follow a path that takes it from one negative terminal of the 125VDC "A" battery to the positive terminal of the 125 VDC "A" battery. Since the 250 VDC batteries are independent, it cannot interact with the 250 VDC system even if both the 125 VDC and the 250 VDC systems have developed ground faults. (It should be noted the ground fault assumed in the white paper is actually the current through the assumed pre-existing fault and the ground detection circuitry of the 125VDC system).

The above does not preclude smart faults traveling through a closed loop if a driving potential exists. However, if one side of the loop is not tied to the 125 VDC battery (i.e., not a closed loop), a ground fault cannot produce a current from that battery. If both sides of some load are grounded (i.e., a load other than from 125 VDC system), there will not be any smart faults through that load since there is not any driving potential through the load. The existing white paper considered all potential closed circuit paths of the 125 VDC system, and no additional loads can be postulated as a result of any grounds of the other DC systems.

The same is also true of the interaction with the AC system. Since one side of the AC system is already grounded, ground represents zero potential and there is no driving force for the AC current through the SRV fuses. (The Weidmuller OE raised questions because it was looking at DC to AC interaction.

However, this was to develop an acceptance criteria for the terminal blocks to make sure DC leakage current would not cross over to the adjourning terminal block and keep the MSIVs open. See the #4 below).

Since each of the two 125 VDC systems, the two 250 VDC systems, and the AC system are all physically and electrically independent systems, there is no additional impact of interaction between the systems on the white paper.

3) The auto-transfer function of SRVs

As stated in #2 above, the 125 VDC "A" system is completely independent of the 125VDC "B" system. The conservative conclusion presented in the white paper is that the 10 amp fuses of the SRVs would NOT open.

To demonstrate the available margin it is postulated one (or all) of the SRV fuses open on the 125 VDC "A" feed to the circuit. If this were to occur, the normally energized power monitoring relay would open the contacts from the "A" side and then close the contacts to the 125 VDC "B" system. This system also provides power to each SRV (and attendant logic) via its dedicated fuse.

From the white paper, the bounding normal amperage through this fuse would be the 1.401 amps for each low low set (LLS) valves (less for the remaining six valves). Since MS-PS-300A-H are part of the logic circuit of the SRVs, the maximum ground fault of 1.13 amps would transfer with the SRV. When added to the bounding normal amperage results in a total of 2.531 amps.

However, the circuits powering MS-PS-256A-H, the MSIVs, and the drywell indicating lights are only powered from the "A" system. Therefore the smart faults assumed for these loads would NOT transfer with the SRV, which precludes these loads from passing through the "B" system fuses.

Similarly, the smart faults originally assumed for RR-MO43A/B and RR-MO53A/B are only powered from the 125VDC "A" system. However, a similar mirror configuration exists in the 125 VDC "B" system. Therefore if the same type of conservative smart fault is assumed to occur in the mirror circuit (i.e., a fault of just the right magnitude to prevent the tripping of the breaker), an additional 3.36 amps and .032 amps is added for a total of 5.923 amps.

This represents 59% of the nominal fuse rating and 54% of the maximum continuous fuse rating. Although not specifically addressed, the auto transfer function provides additional margin and the white paper remains bounding.

4) The impact of DC and AC circuits on the same terminal blocks

The Weidmuller Operability Evaluation (OE) determined the minimum acceptable insulation resistance for various applications of the Weidmuller terminal blocks. This OE evaluated the effect of a DC circuit with an AC coil for the MSIVs.

The Weidmuller OE presented a detailed circuit analysis for all equipment supported by Weidmuller terminal blocks installed in its power source path. Industry reports and NPPD analysis calculated the maximum acceptable leakage current and corresponding minimum acceptable terminal block insulation resistance. To assure the MSIVs would close, the minimum resistance of adjacent terminals was evaluated to make sure the DC current would not keep the AC solenoids energized. The assumed current path is from the positive bus of the 125 VDC system, to the hot side of the coil termination. As the neutral of the AC system is grounded, the current flows through the coil to ground through the ground detection circuitry to the negative bus of the 125 VDC system. (It should be noted this is only possible through a terminal to terminal connection, and if the current path went to ground, to the hot side of the coil termination, no driving force would be present for this current).

The white paper assumed the failure of the MSIVs and the worst case failure has been included in the PSA evaluation. (It should be noted the white paper assumed a failure of the MSIVs to close. However, the failure of a MSIV to close does not result in a worst case PSA, so the PSA assumes the valve to fail in the closed position. This causes the maximum challenge to the core damage frequency, and demonstrates additional margin in the final result).

The SRV circuits were reviewed and it was determined they do not have any common enclosures, terminal blocks, or cables that contain AC power. The same is also true of the MS-PS-300A-H circuits. The only leakage current from the SRV circuits is via the ground path from the MS-PS-300A-H. Since the neutral side of all AC components is grounded, there is no additional leakage current path from the 125 VDC system, and the values used in the white paper remain bounding.

5) The impact of resistance uncertainties in the ground fault analysis.

The NRC inspection report addressed the impact of resistance uncertainties on the maximum calculated ground fault. The maximum calculated ground fault of 1.13 amps is from NEDC 91-197. As stated above, this was a conservative value based on a pre-existing fault just below the detection threshold of the switchgear ground detection circuitry, but well above the detection capability of the battery charger. This was chosen as abounding in the calculation to discuss any concerns of resistance uncertainties in the ground detection circuitry.

The four DC systems (125 VDC A/B and 250 VDC A/B) are separate ungrounded systems. To ensure they remain ungrounded, they each have their own ground detection circuitry. Each system has two ground detection circuitries, one in the switchgear, and one in the battery chargers. This circuitry is connected to both the positive and the negative bus. When a ground fault occurs, a small current passes through the ground to the ground detection relay to the opposite bus. The relay located in the battery charger actuates at a much smaller ground current than the switchgear relay. In addition, lights are provided to determine any current imbalance as a result of a ground fault condition, which are checked at least once per shift.

The lights result in being able to detect any ground fault of ~1000 ohms on either the positive or the negative bus. Similarly, the less sensitive ground detection relays are capable of detecting a ground faults of ~150 ohms on either the negative or positive bus. The actuation of either relay (battery charger or switchgear) alarms in the control room and actions are promptly taken to resolve the degraded condition.

Calculation 91-197 determined the maximum ground fault using the nominal resistance values. However, due to manufacturer tolerances, resistance values can vary by as much as ± 10%. For additional conservatism, if we assume ALL of the resistance values are at twice this minimum tolerance (i.e., - 20%), this results in an additional 0.28 amps to the 1.13 amps included in the white paper for a total of 1.41amps.

Offsetting this additional conservatism is that calculation 91-197 conservatively calculated this maximum fault current assuming a PRE-EXISTING fault of 150 ohms, which would have been a DETECTABLE fault. A review of the past material history and PIRs indicate this has not occurred during the last three years.

If we assume the fault current of a pre-existing NON-DETECTABLE fault (i.e., just below the detection threshold of approximately 1000 ohms) it would reduce the maximum ground fault by 0.75 amps to only 0.38 amps (vice the assumed 1.13 amps). While this reduction uses nominal values, it demonstrates that the assumption of a pre-existing detectable fault envelopes any tolerance/uncertainty considerations.

Therefore, the white paper remains bounding.

6) The various non-conformances associated with Weidmuller terminal blocks

The detailed evaluations for the various non-conformances of the Weidmuller terminal blocks demonstrated that the Weidmuller blocks would not impact the operation of the SRVs.

The white paper did not include any leakage current from the terminal blocks as it was considered to have negligble contribution to the total assumed fault currents. It should be noted that any leakage current to ground is already bounded by the assumed bolted ground fault in the white paper. However, using the worst case tested insulation resistance could result in an additional leakage current from terminal to terminal of less than 10 mA. This is more than enveloped by the assumption of a detectable pre-existing fault, which has been confirmed not to have existed on the 125 VDC "A" system in the last three years.

In addition, the actual as found condition has been determined to be fully qualified. Therefore, the results of the white paper remain bounding.

7) Hypothetical fire as a result of the ground faults opening the SRV power circuit

One question was that the additional fault current could create a fire and burn up the conductor thus preventing any transfer of power to/from the SRVs. However, the total and bounding fault current is less than 7 amps. This was calculated using zero resistance faults, and zero resistance conduction paths back to the ground detection circuitry.

All of the cables inside of the drywell are IEEE 383 fire retardant cables. They are located inside of metal enclosures with no other combustible material available.

Zero resistance faults will not create any heat to generate a fire, and if some resistance is present, the maximum fault currents would be much less. This fact notwithstanding, the amount of energy present in 7 amps is less 1,000 watts (i.e., full float voltage of 132.5 volts time 7 amps is only 927.5 watts). The low energy of the total fault is not sufficient to provide an ignition source for this type of cable, which means that a fire is not considered credible.

Although not credible, any fire would remain localized within the enclosure and would not propagate as the cables are all IEEE 383 type cables. Since the SRV control circuit paths have remained a fully qualified configuration, and the only EQ non-conformance is in the tailpipe pressure switch, this hypothetical fire would remain in the enclosure for the tailpipe pressure switch. Since the SRV control circuit is in parallel with the tailpipe pressure switch and in separate enclosures, any impact from this hypothetical fire would not impact the SRV circuit.

In addition to the separate enclosures, the devices are also physically separated, which further protects the impact to the SRVs. The pressure switches are physically located above and to the side of the SRV and connecting cable.

Finally, the post-accident drywell condition of water, steam, and nitrogen (i.e., inerted) environment further precludes any fire. Therefore the white paper remains bounding.

8) Do the SRVs have adequate voltage with the additional voltage drop from the fault currents

The SRV control leads are in parallel with the leads to the pressure switches after they leave the control building panel 9-45. The assumed fault currents through the ground detection circuitry and the other assumed smart faults would create additional voltage drop to the tailpipe pressure switch, but would not impact the SRV circuits except the shared path from the positive battery to panel 9-45. (It should be noted that the faults are taking different paths back to the negative battery terminal. Therefore only the one way circuit path from the positive bus to panel 9-45 is shared.)

In addition to determining the loading on the 125 VDC battery, NEDC 87-131C calculates the voltage drop to the SRV using the normal SRV current. It assumes the 1.13 amps of ground fault current in the total battery loading. However, this current does not apply this specifically apply to any one circuit and it will be added to the remaining fault currents to determine additional voltage drop. The normal SRV amperage assumed in the white paper is 1.4 amps, which leaves 6.9 amps of additional current.

Per NEDC 87-131C, the resistance between the batteries and panel 9-45 is 0.728 ohms. This value is a two-way path (i.e., from the positive terminal to panel 9-45 and from panel 9-45 to the negative terminal) and the one way path would be ½ of this amount, which is 0.364 amp. If 0.4 ohms is assumed, the resultant fault current of less than 7 amps would result in no more than an additional 2.8 volt drop to panel 9-45.

Also per NEDC 87-131C, the minimum acceptable voltage for the SRV is 92 volts, which corresponds to 94.1 volts at the distribution panel AA2. The minimum calculated voltage at this point is 103.2 volts which leaves 9.1 volts of margin at the peak current conditions for any voltage drop considerations. In addition as previously stated, this peak will not occur at the same time as the SRV would operate, but to do so conservatively maintains additional margin.

It should be noted, this maximum fault current is a bounding value was calculated using full float voltage of the battery chargers. However the calculated minimum voltage is assumes no chargers. This adds additional margin to assure the results remain bounding.

9) What are the various permutations and how do we know we have accounted for all of them

The EQ non-conformances identified outside of the drywell are not deleteriously impacted by a LOCA. That leaves only the electrical equipment inside of the drywell.

Since the 125VDC, 250VDC, and various AC systems are physically and electrically independent, interaction at the SYSTEM level will not occur. This is due to the fact that any current path must be a closed loop from the source to a load and back to the SAME source. Therefore, while local leakage current from one system may impact a COMPONENT (such as the AC system can energize the DC solenoid valve and impact the MSIVs), it cannot impact the SYSTEM.

In addition, local fusing protects each of these systems. The short circuit and fuse coordination studies (NEDC 86-105 series and NEDC 91-197) already bound any of the faults that may be created by the various EQ non-conformances.

This short circuit study has already evaluated bolted fault conditions to ground, and bolted short circuits (i.e., phase to phase or positive to negative) and concluded that the fusing will clear prior to exceeding the damage curves of the cables or penetrations. In addition, the coordination study has concluded that adequate fusing exists such that any localized fault will be cleared by the fuse at the distribution level without impacting any of the remaining equipment fed from that distribution center. Therefore, it can be concluded that the various EQ non-conformances will not create a SYSTEM wide failure of the 125 VDC, 250 VDC or various AC system or create any interaction between the systems during a LOCA.

Since we have determined the non-conformances will not adversely impact the electrical distribution system, we next looked at the individual components. To assure that we have captured all of the information, the entire list of equipment from the electronic data file (EDF) was used, and the non-electrical components were screened off of the list, which resulted in a complete list of the electrical components in the drywell.

For every component that was not EQ, or that some EQ non-conformance was found, the equipment was assumed to fail. The impact of these failures was addressed in the PSA analysis. In addition, the as-found database was used to identify each non-conformance. Drawings were reviewed to determine what physical separation from other equipment was provided.

If the equipment shared the same enclosure, an evaluation to determine any interaction from other electrical systems that would cause mal-operation of the qualified device was performed. In most cases, the devices had already been assumed to fail. The sole exception is the SRV solenoid circuit path. This path shares common enclosures with other EQ non-conformances in the electrical penetrations. However, the evaluation in the OE for PIR 4-12831 determined that the SRV circuit would not be impacted as long as at least 0.9k ohms of insulation resistance between it and any other circuit is provided. The SRV circuit path inside of the penetrations is qualified cable with a qualified Raychem splice. This configuration provides at least three orders of magnitude higher insulation resistance than is required.

Conclusion

This addendum evaluates various additional questions and non-conformances which have occurred since the original white paper on past operability of the SRVs was completed. This addendum demonstrated the original white paper remains a bounding evaluation and identifies additional conservatism in the original evaluations.