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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

December 20, 2000

MEMORANDUM TO: William D. Travers
Executive Director for Operations

FROM: John T. Larkins, Executive Director
Advisory Committee on Reactor Safeguards

SUBJECT: PHYSICAL SEPARATION OF CIRCUITS FOR LOW PRESSURE EMERGENCY CORE COOLING SYSTEMS

The purpose of this memorandum is to forward information received from Mr. Andy Bartlik, a member of the public, concerning the adequacy of electrical circuit separation at the James A. FitzPatrick Power Plant. Mr. Bartlik contacted Dr. Dana Powers, ACRS Chairman, and e-mailed him the attached documents. Mr. Bartlik contends that the NRC staff has not adequately reviewed or acted on this issue. I understand that the staff is reviewing the issue of electrical circuit separation and expects to reach a resolution by the end of February 2001. The ACRS would like to have an opportunity to review the staff's resolution when available.

Attachments:
1. E-mail from Andy Bartlik to Dana A. Powers, Chairman, ACRS, Subject: SIL-630 and Related Deficiency Report, dated November 20, 2000.
2. General Electric Nuclear Energy Services Information Letter SIL No. 630, "Physical Separation of Circuits for Low Pressure Emergency Core Cooling Systems," dated July 17, 2000.
3. Deficiency Evaluation Report DER-00-00064, "Apparent Deficiencies with NEDO-10139," undated.

cc: A. Vietti-Cook, SECY
J. Craig, OEDO
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S. Collins, NRR
J. Calvo, NRR
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GT 160

From: "Powers, Dana A" <dapower@sandia.gov>
To: "'jtl@nrc.gov'" <jtl@nrc.gov>
Date: Mon, Nov 20, 2000 5:45 PM
Subject: FW: SIL-630 and Related Deficiency Report

John,

This is some of the written material Bartlik cited during our conversations.

Dana

----Original Message----
From: Bartlik, Andrew [mailto:Andrew.Bartlik@nypa.gov]
Sent: November 20, 2000 12:46 PM
To: 'dapower@sandia.gov'
Subject: SIL-630 and Related Deficiency Report

Dana,

Attached is a copy of SIL-630 as well a related deficiency report. I do not have a copy handy, but the GE PRC associated with the issue is PRC-00-02.

Let me know if you require any clarification.

Andy Bartlik
914-272-3480

<<Sil630.pdf>> <<DER-00-00064.doc>>

ATTACHMENT 1

Physical separation of circuits for low pressure Emergency Core Cooling Systems

SIL No. 630

July 17, 2000

The owner of a GE BWR/4 plant located in the United States recently identified a concern related to separation of electrical circuits for low pressure Emergency Core Cooling Systems (ECCS) within the same electrical division. GE Nuclear Energy performed an evaluation addressing the potential effects of an electrical failure on the single failure assumptions supporting plant loss-of-coolant accident (LOCA) analyses. No plant design deficiencies have been identified, and GE has determined that this concern could not create a substantial safety hazard or contribute to the exceeding of a technical specification safety limit. However, the results of the evaluation indicate that the plant electrical separation specifications for certain GE BWR/3 and /4 plants may not provide sufficient information to assure adequate electrical separation between certain safety-related components required to perform the ECCS function.

The purpose of this SIL is to discuss the GE evaluation and to recommend that owners of affected GE BWRs review and, if necessary, clarify documented plant separation requirements. This SIL applies to GE BWR/3 and /4 plants having Low Pressure Coolant Injection (LPCI) subsystems that were originally provided with loop selection logic, including those plants that subsequently eliminated loop selection logic (e.g., the "LPCI modification").

Discussion

The majority of GE BWR/3 and /4 plants were designed, prior to the issuance of 10CFR50.46 and 10CFR50 Appendix K, with low pressure ECCS consisting of a LPCI subsystem and a Core Spray (CS) system to provide diverse core cooling methods (flooding and spray cooling). The two 100% capacity CS subsystems and one LPCI subsystem (with four 33.3% capacity pumps) were separated into two electrical divisions, and redundant electrical circuits from the two divisions were provided for certain motor-operated valves (MOVs) in the LPCI subsystem. The LPCI subsystem was originally designed with loop selection logic to direct LPCI flow to the intact recirculation loop following a postulated Recirculation System pipe break. Any of the three subsystems was capable of providing the required core cooling function, and LOCA analyses demonstrated that the original design requirements were met even with complete loss of all equipment in one of the two electrical divisions.

Implementation of the 10CFR50.46 acceptance criteria with the Appendix K requirements for evaluation models and single failure assumptions resulted in very restrictive core operating limits. However, based on single failure analysis, credit could be taken for availability of more than one of the three low pressure ECCS subsystems (either two CS subsystems or one CS subsystem and at least partial functionality of the LPCI subsystem). In addition, several plants implemented the LPCI modification to increase post-LOCA core cooling capability to minimize the impact of these new requirements on core operating limits.

When performing plant LOCA analyses, GE requests that BWR owners identify the remaining ECCS subsystems available following postulated single failures consistent with the current plant licensing bases. The original plant separation requirements were adequate to assure that postulated single failures could only affect equipment in one electrical division. However, for some specific failure scenarios, these requirements may not be adequate to assure the

validity of assumptions supporting analyses to demonstrate compliance with the more conservative requirements of 10CFR50.46 and 10CFR50 Appendix K.

Two particular scenarios may be of concern if fault-limiting devices in the affected circuits are not adequate to prevent failure propagation. These scenarios are:

1. single failures in other systems that could credibly propagate within one division to both the LPCI (including recirculation pump discharge valve) and CS circuits within that division; or
2. single failures in either the LPCI (including recirculation pump discharge valve) or CS circuits in one division that could credibly propagate to the other subsystem within that division (i.e., LPCI to CS, or CS to LPCI).

The consequences of such postulated failures could invalidate the limiting single failure assumptions supporting the plant LOCA analysis. The original plant separation requirements would not have prevented these failure scenarios, but actual plant design implementation may be adequate to assure that such failure scenarios are not considered credible.

For known cases where additional intra-divisional separation requirements were established, reviews have identified that the plant electrical separation specifications were not revised to include these additional requirements. If these requirements are not properly documented and fully understood, the electrical cables for certain CS MOVs and LPCI MOVs (including the recirculation pump discharge valve) in the same division might be routed in the same wireways, and an electrical failure could potentially result in a reduction in ECCS capacity below the level assumed in the plant LOCA analysis. In addition, plant modifications, including the LPCI modification, might inadvertently violate these requirements.

Recommended action

GE Nuclear Energy recommends that owners of GE BWR/3 and /4 plants having LPCI subsystems that were originally provided with loop selection logic take the following actions:

1. Review plant electrical separation specifications, ECCS documentation, and associated licensing bases and commitments to determine if currently documented separation requirements are adequate to assure continued validity of the limiting single failure assumptions supporting the plant LOCA analysis.
2. If necessary, update plant electrical separation specifications.

To receive additional information on this subject or for assistance in implementing a recommendation, please contact your local GE Nuclear Energy Service Representative.

This SIL pertains only to GE BWRs. The conditions under which GE Nuclear Energy issues SILs are stated in SIL No. 001 Revision 6, the provisions of which are incorporated into this SIL by reference.

Product reference

E11— Residual Heat Removal (LPCI subsystem)
E21— Core Spray
R00—Plant Electrical

Issued by

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DER-00-00064
Apparent Deficiencies with NEDO-10139

Objective:

The objective of this document is to describe an error in the methodology employed by NEDO-10139, which when considered in conjunction with the plant electrical separation, may potentially have resulted in functionally redundant cables, critical to ECCS operation, to being installed in a common wireway. Where applicable, this document will also discuss the post VY configuration of the facility.

Background:

The electrical separation criteria applicable to James A FitzPatrick Power Plant, requires that cables associated with Division A and B systems and equipment, be installed in a separate set of wireways, to minimize the potential for the loss of "redundant equipment", should a wireway be destroyed by a physical event. When this separation criteria was established, it was believed that a single Core Spray pump, augmented with either the Automatic Depressurization System (ADS) or the High Pressure Coolant Injection (HPCI), would be adequate for the full spectrum of Loss of Coolant Accidents (LOCAs).

During the licensing process, the above redundancy paradigm, was determined to be inadequate. This was in part due to changes in the ECCS performance requirements directed by the NRC in the Interim Acceptance Criteria (IAC). In addition, it had been determined that a single core pump may not be capable of achieving the design spray density on all fuel bundles.

In response to these issues, General Electric defined alternate redundancy paradigms, which credit either simultaneous operation of two LPCI pumps and one Core Spray pump, or the simultaneous operation of two (previously thought to redundant) Core Spray pumps.

The survival of at least one of the above described redundancy arrangements to an assumed loss of a single wireway is not necessarily assured by the established electrical separation criteria. This is because each of the above redundancy paradigms can rely on equipment of both established divisions simultaneously. This is readily apparent for the "Two Core Spray Pump" accident response strategy, as a large fraction of both Division A and B components would be required to function in concert, in order to ensure two core spray pumps would be available. Although less obvious, this is also true for accident response utilizing "Two LPCI pumps and One Core Spray pump".

Although the LPCI system has many independent Division A and B components, successful LPCI operation can simultaneously require proper function of both Division A and B components. For example, for plants which have not implemented the VY modification, for a recirculation suction line break on the A side of the plant, with the Division A LPCI response, the Division B LPCI injection valves must function. Recognizing this dual division dependence, General Electric assessed the capability of the ECCS to respond assuming a large range of failures, including the physical destruction of a wireway. This analysis is documented in NEDO-10139.

Although, the redundancy arrangements are more complex, and too difficult to describe in a brief background statement, a redundancy paradigm relying on two of the established divisions simultaneously is also relied upon for plant which have implemented the VY modification.

Problem Statements:

In NEDO-10139, General Electric represented that a failure, resulting in the loss of a wireway segment which, can totally defeat the LPCI function, would not in anyway affect either division of Core Spray. The review performed by General Electric appears to have not included all cables critical to ECCS operation and consequently has not actually demonstrated that failures in wireway segments which can totally defeat LPCI, is in fact independent of both divisions of Core Spray as claimed by NEDO-10139. The following lists specific reviews, which should have been performed, but appear to have not been:

<u>Wireway Failures Associated with the LPCI Injection Valve</u>

General Electric's assessment of the independence of Core Spray and LPCI did not include the wireways which contain the control cables from the LPCI control panel to the LPCI bus itself. The existing electrical separation criteria does not specify any special routing criteria for these cables, which would ensure their independence from cables necessary to support both divisions of Core Spray. Consequently, it is indeterminate if physical separation and independence is actual present as claimed.

In addition, the 600 volt power feeder to the injection valves themselves, do not have any special routing criteria. On a similar basis as described above, it is indeterminate if physical separation and independence is actually present as claimed.

The LPCI injection valve have auxiliary relay contacts in the control circuit of the valves. The failure of these control inputs could block proper function of the injection valves.

The physical routing of cables which transmit the signals from the instruments in the field to the logic panels has not been considered and been demonstrated to be independent of both divisions of Core Spray. For example, 10MOV-25A (one of the Division A LPCI injection valves), has a contacts associated with relays 10A-K63A and 10A-K66, in the closing circuit. Although these relays themselves are located in logic cabinet 9-32, failure of cables associated local devices can complete the closing coil circuit, causing the valve to cycle closed. This can occur even with an opening signal from Division B sources present. With both an opening and closing signal present, the valve would continually cycle between the open and closed position, potentially depleting the battery. Similar contact sets can be found in 10MOV-25B. Other RHR and CS valve control circuits should also be examined to determine if similar conditions are present.

Effect of Failure of Non-Automatic Valves on ECCS Response

The General Electric review in NEDO-10139 does not appear to include valves which are not required to operate to support proper ECCS function. The malfunction of some non-automatic valves can adversely affect ECCS function. For example, the spurious opening of the suppression pool cooling return flow path could divert LPCI injection flow to the torus. Although this flow path would be expected to be blocked by two valves in series, both these valves are of the same division, with no special routing criteria, and my be installed in the same wireway, and subject to common mode failure. As failure of theses valves can directly disable both divisions of LPCI, both divisions of Core Spray should have been shown to be independent of the control circuitry of these valves. A similar condition may apply to the drywell spray valves isolation valves, and to a lesser extent the wetwell spray isolation valves.

For plants which have implemented the VY modification, the spurious closure of the by-pass valve around the RHR heat exchanger could block LPCI flow from two pumps of opposite divisions. Based on the redundancy paradigm applicable to plants which have implemented the VY modification, wireway failures along the routing of cables which can cause the spurious closure of this valve should be demonstrated to be independent of both divisions of Core Spray and the RHR pumps injecting in the alternate loop. This independence is not assured based on the established electrical separation criteria for the facility. In addition, based on a review of a July 24, 1975 submittal to the NRC relative to the VY modification at JAF, it is not apparent that the necessary review, required to show the required level of physical separation, was preformed during implementation of the modification. A similar condition appears to be applicable to the RHR mini flow valves of plants which have implemented the VY modification.

DER-00-00064

Apparent Deficiencies with NEDO-10139

Failure to Establish Adequate Administrative Controls to Maintain Plant Design Basis

NEDO-10139 established a new redundancy paradigm, which essentially required different electrical separation criteria than in place at JAF. NEDO-10139 attempted to show that adequate electrical separation was present to support this new redundancy arrangement. However, NEDO-10139 fell short of actually calling for revision to the electrical separation specifications, to ensure that the new redundancy arrangement maintained the required level of electrical independence. Consequently, it appears that design control measure, in accordance with the requirements of 10CFR50 Appendix B, Section III, have not been established. Absent appropriate design control measures, it is possible that design changes could have placed the facility in non-compliance with it's design basis.

Based on discussions with knowledgeable engineer, in responsible charge at the facility, the above described redundancy paradigms are neither thoroughly understood nor known. An example of a modification which may have decreased the level of independence below the required degree is modification F1-91-305, titled "LPCI Alternate Power Supply Circuit Modification". This modification routed circuits, whose failure could potentially disable one of the LPCI independent power supply circuits, in the general raceway system, applying train assignment as the primary criterion. The modification makes no mention of any special separation requirements applicable to circuits associated with LPCI, which also need to be independent of both divisions of Core Spray as well as the LPCI pumps of the alternate loop.

Conclusion:

Due to the large number of circuits involved, and the complex redundancy arrangements established by the current accident analyses, it is unlikely that functionally redundant sets of equipment actually have the extent of physical independence as contemplated in the NEDO-10139 and the July 24, 1975 submittal to the NRC.