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TO ALL BWR APPLICANTS AND LICENSEES

January 3-1986

Gentlemen:

SUBJECT: SAFETY CONCERNS ASSOCIATED WITH PIPE BREAKS IN THE BWR SCRAM SYSTEM (GENERIC LETTER 86-01)

On April 10, 1981, the NRC staff sent a generic letter to all BWR applicants and licensees requesting them to provide their plant specific responses addressing the concerns identified in Draft NUREG-0785, "Safety Concerns Associated with Pipe Breaks in the BWR Scram System." On August 31, 1981 the staff sent Generic Letters 81-34 to BWR licensees and 81-35 to BWR license applicants, wherein it was stated that plant specific responses conforming to the guidance contained in NUREG-0803, "Generic SER Regarding Integrity of BWR Scram System Piping" would satisfy the request for information in the April 10, 1981 letter. In Generic Letter 81-35, the staff further stated that pipe failure in the BWR scram system is not a safety issue for the Mark III containment designs.

The NUREG-0803 guidelines essentially addressed the need for improvement in procedures, periodic inservice inspection and surveillance for the scram discharge volume (SDV) system, and environmental qualification for essential equipment needed for mitigation of the consequences of staff-postulated pipe failures in the SDV piping system. These guidelines were developed to address the consequences of a postulated leakage crack in the SDV piping and resulting large leakage (up to 550 gpm) downstream of the system isolation valves. Such a leak would have the potential to cause degradation of the needed mitigation equipment. At the time they were developed, these conservative assumptions and guidelines were based on 1) lack of generically identifiable failure mechanisms for the SDV piping system, 2) scarcity of available data for the system including uncertainty regarding the operability of mitigation equipment in a possibly harsh environment, and 3) lack of adequate guidance in the BWR Owners Group (BWROG) Emergency Procedure Guidelines (EPGs) for handling reactor building and environmental problems that may arise as a consequence of such an accident.

Based on its review of BWROG and General Electric Company (GE) supplied generic information (NEDO-22209, BWROG-8325 and BWROG-8420) and staff generic analyses of the SDV piping system integrity, the staff has concluded that in accordance with Branch Technical Position (BTP) MEB 3-1, Position B.2.e in Standard Review Plan 3.6.2, through-wall leakage cracks instead of breaks may be postulated in the piping of those fluid systems that qualify as high-energy fluid systems (temperature greater than 200 degrees F or pressure greater than 275 psig) only for short operational periods (about 2 percent of the time) but qualify as moderate energy fluid systems (temperature less than or equal to 200 degrees F and pressure less than or equal to 275 psig) for the major operational period. Furthermore,



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the staff has concluded that, based on its classification and low stress threshold, the SDV piping system satisfies BTP MEB 3-1, Position B.2.c(1) in that a through-wall leakage crack need not be postulated.

Since the SDV piping system fulfills the above criteria, breaks and through-wall cracks in the SDV piping need not be postulated. In addition, the staff has concluded that, even if a staff-postulated through-wall flaw is initially present in the SDV system, it will grow negligibly and will not propagate into a break under the staff defined piping loads. Further, leakage from such a flaw will be small (less than or equal to about 5 gpm) and, therefore, a harsh environment over large areas of the reactor building which could affect redundant safety-related mitigating equipment will not result. Thus, the potentially exposed safety-related equipment need not be qualified for operation in a harsh environment associated with an SDV break.

The staff has also concluded that the revised BWROG Emergency Procedure Guidelines for secondary containment control (NEDO-24934), together with normal plant procedures and the proposed periodic visual verification of the scram system piping integrity (BWROG-8420), provide sufficient measures for detecting and mitigating the consequences of leakage which may occur in the SDV piping system. The design basis of the SDV piping system has considered transient forces resulting from the worst case control rod drive (CRD) system actuation. Although water hammer has been analytically postulated and hydraulic instabilities have been experienced in the CRD system, no events have been experienced of a severity significant enough to constitute a water hammer. Therefore, water hammer is not considered a contributing factor in potential SDV pipe breaks.

Accordingly, this completes our review of the safety concerns associated with pipe breaks in the BWR scram system. No OMB clearance is required since no information is requested.

This information is being provided to BWR applicants and licensees with Mark III Containments for informational purposes only.

Original Signed By
Robert M. Bernero

Robert M. Bernero, Director
Division of BWR Licensing

Enclosure:
Staff Safety Evaluation

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Enclosure

# GENERIC SAFETY EVALUATION REPORT REGARDING INTEGRITY OF BWR SCRAM DISCHARGE PIPING SYSTEM

## 1.0 Introduction

### 1.1 NUREG-0803, Bases and Assumptions

During the investigation of the Browns Ferry Unit 3 control rod partial insertion event on June 28, 1980, the NRC staff identified potential safety concerns associated with postulated pipe failures in BWR scram discharge piping systems. These concerns were documented in a draft report entitled, "Safety Concerns Associated With Pipe Breaks in the BWR Scram System" (NUREG-0785) published on April 3, 1981. Subsequently, the NRC sent a Generic Letter (letter, D. G. Eisenhut, April 10, 1981) to all BWR licensees requesting them to address the concerns identified in NUREG-0785. In response to this letter, and after a conference with the NRC staff, the General Electric Company (GE) provided generic topical report NEDO-24342, "GE Evaluation in Response to NRC Request Regarding BWR Scram System Pipe Breaks" by letter dated April 30, 1981. This generic submittal was reviewed by a multidisciplinary staff group. During the course of the review, the staff issued a report entitled "Generic Safety Evaluation Report Regarding Integrity of BWR Scram System Piping" (NUREG-0803) for resolving this matter. In this report, the staff provided specific guidelines and criteria to BWR licensees which was meant to ensure (1) the integrity of the scram discharge volume (SDV) piping system, (2) the leak detection and mitigation capabilities for the staff postulated piping failure in the system and (3) the qualification of essential equipment (needed for detection and mitigation) exposed to the expected environment resulting from the postulated failure.

Following the publication of NUREG-0803, the NRC sent Generic Letters 81-34 and 81-35 dated August 31, 1981 (NRC letters, D. G. Eisenhut) to all the BWR licensees and applicants requesting them to provide their plant specific responses to the NUREG-0803 guidelines within a stipulated period. The bases for these guidelines are summarized below:

At the time the NUREG-0803 guidelines were formalized, the staff found

1. lack of generically identifiable failure mechanisms for the SDV piping system and scarcity of available data for the system;

2. lack of adequate information on the capability to detect a postulated failure in the system piping in a timely manner to permit corrective operator actions to mitigate the consequences of such a failure;

3. lack of adequate guidance in the BWR Owners' Group (BWROG) emergency procedure guidelines (EPG) for handling reactor building and environmental problems that may arise as a consequence of an accident; and

4. uncertainty regarding the operability of essential equipment needed for mitigation since it may not be environmentally qualified for the local conditions that may exist under the postulated SDV piping failure.

NUREG-0803 recognized that the safety concerns that stem from possible consequences in the reactor building resulting from a postulated leakage crack in the SDV header piping will not be applicable to BWRs with Mark III containment designs, because the safety-related mitigation equipment is not located in the reactor building, but will be applicable to Mark I and II containment designs. The staff, however, concluded that the leak rate from the postulated pipe failure in the SDV piping system assumed by GE in NEDO-24342 was reasonable. Specific guidelines were developed which conservatively assumed that a leakage crack (equivalent break area of about 0.007 $ft^2$) occurs in the SDV header piping system following a scram but before the scram is reset and that it results in fluid leakage at a rate of up to 550 gpm downstream of the system isolation valves. In developing these guidelines, the staff additionally considered the potential for this large leakage to cause degradation of the mitigation equipment, particularly if the piping failure can not be isolated.

In NUREG-0803, the staff used an estimated SDV piping failure frequency of $10^{-4}$ per plant year in the generic risk assessment analysis. Given the lack of generically identifiable failure mechanisms for the SDV piping failure at that time when NUREG-0803 was prepared, the staff regarded the estimated frequency to be extremely conservative. However, the staff acknowledged the uncertainty of the estimate because of the assumptions that were made and the scarcity of the available data at that time.

Using the above value and assuming that the required mitigation equipment will be operable, a core melt frequency of $10^{-6}$ per plant year was estimated. It was concluded that the sequence of events following the postulated SDV piping failure analyzed in the report will not be a dominant contributor to core melt, provided the required mitigation equipment is not degraded by the adverse SDV pipe failure environment.

## 1.2 BWROG Response To NUREG-0803 Concerns, NEDO-22209

In response to NRC generic letters 81-34 and 81-35 relating to the concerns identified in NUREG-0803, the BWROG submitted a GE topical report entitled "Analysis of Scram Discharge Volume System Piping Integrity" (NEDO-22209) by letter dated August 23, 1982 and a correction letter dated October 26, 1982 (BWROG-8259). In this report, based on their analysis of SDV piping data for 15 BWRs, the BWROG calculated a probability of $3 \times 10^{-7}$ per plant year for an unisolatable loss of SDV piping integrity and a probability of $4 \times 10^{-11}$ events per reactor year for core damage resulting from such a loss of integrity. The BWROG contended that, therefore, there was no need for qualifying the equipment required to detect and/or mitigate the consequences of such a low probability event. Based on a review of the above submittals (NEDO-22209; BWROG-8259), the staff requested additional information from the BWROG in a number of areas (NRC, notes of meeting held on February 2, 1983). Included in this request was a concern regarding the effect of a seismic event on SDV piping integrity and its effect on the SDV pipe failure probability indicated in NEDO-22209. By letters dated January 28, 1983 and June 29, 1983 (BWROG-8303; BWROG-8325), the BWROG provided the requested responses. Specifically, in their June 29, 1983 response, the BWROG determined that the probability of SDV pipe failure from seismic loads was of approximately the same magnitude as the probability of pipe failure from other sources, they had calculated earlier. Consequently, the BWROG concluded that the statements given in NEDO-22209 were still valid.

## 1.3 Deterministic Fracture Mechanics Evaluation

Based on the staff's review of the BWROG response (NEDO-22209; BWROG-8259; BWROG-8303; BWROG-8325), it was concluded that an expeditious resolution of the concerns relating to the SDV piping system integrity required a more detailed consideration of the applicable break mechanisms than that which could be obtained from a probabilistic analysis. Therefore, by letter dated July 25, 1983 (NRC letter, D. G. Eisenhut to T. J. Dente), the staff requested the BWROG to provide information in connection with a deterministic fracture mechanics evaluation of the SDV piping integrity along with a discussion of the associated realistic leak rate, leak detection and mitigation capabilities. Specifically, the staff requested the BWROG to provide the following information:

1. Perform a fracture mechanics evaluation which is bounding in terms of leak rate, loading conditions, and material properties for the scram system piping. As a minimum, the following specific conditions should be met:

    a. the postulated through-wall flaw size (length) shall be equal to or greater than twice the pipe wall thickness;

    b. the piping loads applied for flaw stability analysis shall be those associated with normal plant conditions in combination with the Operating Basis Earthquake (OBE); however, for flaw leakage calculations, only piping loads associated with normal plant conditions shall be used;

c. the flaw should be postulated to be located at the highest stressed region in the material with the most limiting properties, i.e., base materials or weld material as applicable;

d. valid material test data should be used in the evaluation; and

e. the leak rate should be calculated for the above postulated through-wall flaw. In addition, a comparison of the calculated leak rate with experimental results and/or operational experience should be provided.

2. Leakage detection capability should be demonstrated to be sufficient to provide adequate margin for detecting leakage from the postulated circumferential through-wall flaw. A discussion should be provided regarding the capability to detect the leak in the scram system piping and take the necessary action to terminate the leakage prior to exceeding the environmental qualification envelope of any affected essential equipment, i.e., necessary for prompt depressurization and long-term cooling. This should include consideration of potentially harsh environments which may limit access for local manual actions. Consideration should be given to making appropriate modifications to existing procedures for prompt depressurization in order to assure that they would cover the above postulated leakage condition and the available plant-specific leak detection devices.

3. Provide a discussion regarding the expected radiation field and contact exposure level at the scram system piping as it may affect routine tests and inspection.

In response to the above letter (NRC letter, D. G. Eisenhut to T. J. Dente), the BWROG provided submittal BWROG-8335 by letter dated November 18, 1983. The submittal, included a deterministic fracture mechanics evaluation of the BWR SDV piping system assuming the staff postulated circumferential through-wall flaw, and piping loads. On the basis of the analysis, the BWROG concluded that the flaw will remain stable and thus will not propagate into a break. The BWROG further concluded that the leak from the flaw will be sufficiently low ($\leq$ 3.5 gpm) that it will not pose a threat to the environmental qualification envelope for equipment in the reactor building needed for detection of the leak and mitigation of its consequences.

## 1.4 Subsequent Developments

Based on the staff's review of BWROG-8335 and other submittals (NEDO-22209; BWROG-8259; BWROG-8303; BWROG-8325), it was concluded that sufficient generic information on the SDV piping system had been provided to warrant a new approach to the SDV pipe break concern rather than applying the criteria of NUREG-0803 for resolving this generic issue. Specifically, the staff concluded that the NUREG-0803 postulated through-wall leakage crack in the SDV piping system should be re-evaluated against the current licensing pipe break criteria of SRP Sections 3.6.1 and 3.6.2 (NUREG-0800; see particularly BTP MEB 3-1, Position B.2.c.(1)]. The staff further concluded that if such a re-evaluation confirms that the SDV piping stress levels are low enough to preclude the need for postulating the through-wall leakage crack, then the SDV pipe crack and its resulting consequences as identified in NUREG-0803 need not be addressed. Additional information was therefore requested on certain aspects of the BWROG November 18, 1983 submittal in a conference call on January 19, 1984 and during a subsequent meeting with GE and BWROG representatives on February 23, 1984 (NRC, notes of meeting). In the meeting, GE provided responses to staff questions raised in the conference call. Additionally, the BWROG submitted a revision dated May 10, 1984 (BWROG-8420) to their original submittal of November 18, 1983 (BWROG-8335), wherein they included the requested information. Specifically, in the May 10, 1984 submittal (BWROG-8420), the BWROG (1) outlined their generic program for periodic visual observation of the SDV piping to check for leaks and (2) outlined the generic emergency procedure guidelines provisions given in the GE Topical Report NEDO-24934 for handling problems arising from pipe breaks outside the containment such as SDV pipe break, and (3) provided a calculation of leak rates associated with the staff postulated flaw for the maximum and minimum SDV header pipe sizes. Furthermore, in the submittal the BWROG reiterated their earlier conclusions regarding the unlikelihood of a leakage crack in the SDV piping system, the stability of the staff postulated flaw should it be initially present, and its minimal environmental consequences on essential equipment exposed to the leak environment should the leak occur.

Based on a review of the May 10, 1984 submittal (BWROG-8420), and other submittals mentioned above and their own analysis of the SDV piping system integrity, the staff has determined that the earlier bases for the conservative assumptions identified in NUREG-0803 are no longer applicable. It was also determined that a leakage crack in the SDV piping system need not be postulated since it has confirmed that the bounding stress values identified by the BWROG satisfy the low stress criteria for moderate energy fluid piping systems given in SRP Section 3.6.2 (NUREG-0800).

The staff's evaluation of the integrity of the system is given below. Adopting a "defense-in-depth" strategy, this evaluation addresses (1) the acceptability of SDV piping stress levels against the SRP criteria for postulated crack locations and the conclusion regarding no break or no through-wall leakage crack determination for the SDV pipe, (2) the acceptability of the BWROG deterministic fracture mechanics evaluation of the SDV piping system integrity along with the probabilistic fracture mechanics analysis and the conclusion regarding the stability of the staff postulated flaw should it be initially present, and (3) the acceptability of the detection and mitigation capability should the leak occur.

## 2.0 Evaluation Of The SDV Piping System Integrity

### 2.1 Evaluation Of The Applicability Of Piping Failure Postulation In The SDV Piping System

This section deals with the staff's evaluation of the applicability of a postulated piping failure in the SDV piping system against current SRP licensing criteria for postulating pipe failures as stated in SRP Section 3.6.2, specifically BTP MEB 3-1 Positions B.2.e and B.2.c.(1) and reiterated in SRP Section 3.6.1 (NUREG-0800).

General Design Criterion (GDC) 4 of 10 CFR 50, Appendix A, requires that structures, components and systems important to safety be designed to accommodate the effects of postulated accidents, including appropriate protection against the dynamic effects of postulated pipe rupture. Specific guidance for meeting GDC 4 with regard to pipe rupture is provided in SRP Sections 3.6.1 and 3.6.2 (NUREG-0800)and the attached Branch Technical Positions BTP ASB 3-1 and BTP MEB 3-1. This guidance includes among other things, the conditions under which a piping failure need not be postulated in a piping system.

BTP MEB 3-1, Position B.2.e permits that through-wall leakage cracks instead of breaks may be postulated in the piping of those fluid systems that qualify as high-energy fluid systems (temperature > 200°F or pressure > 275 psig) only for short operational periods (about two percent of the time) but qualify as moderate energy fluid systems (temperature ≤ 200°F and pressure ≤ 275 psig) for the major operational period. Since the SDV piping system fulfills the above criteria, breaks in the SDV piping need not be postulated.

The SDV piping is normally classified as Class 2. However, some plants have Class 1 SDV piping. BTP MEB 3-1, Position B.2.c.(1) permits that the through-wall leakage cracks in piping systems need not be postulated where the maximum stres intensity is less than 1.2 $S_m$ for Class 1 piping and the maximum stress is less than 0.4 (1.2 $S_h$ + $S_A$) for Class 2 piping. $S_m$ is the design stress intensity for Class 1 piping material as defined in NB-3600 of the ASME Code, Section III and the values for $S_m$ are tabulated in ASME Code, Section III, Division 1, Appendix I Tables. $S_h$ and $S_a$ are the allowable stress at maximum (hot) temperature, and allowable stress range for thermal expansion, respectively, as defined in Article NC-3600 of the ASME Code, Section III.

The piping materials used in the SDV piping are SA 106 Gr. B and C carbon steel and SA 358 304L stainless steel (BWROG-8420). The maximum stress intensity (including SSE loads) for Class 1 design piping is 15 ksi (BWROG-8420). The design stress intensities ($S_m$) for Class 1 piping are 20 ksi, 22.9 ksi and 15.8 ksi for SA 106 Gr. B, SA 106 Gr. C and SA 358 304L at 400°F respectively (ASME Code Section III, Division 1, Appendix I, Tables I-1.1 and I-1.2). Thus it can be seen that Class 1 piping in the SDV piping system satisfies the criteria for not postulating a through-wall leakage crack as stated in BTP MEB 3-1, Position B.2.c.(1). A study of different SDV Class 2 pipe sizes found that the maximum stresses (including SSE loads) were 5.14 ksi, 10.34 ksi and 7.3 ksi for 4 inch, 12 inch and 24 inch pipes respectively (BWROG-8420). The mechanical properties of the Class 2 SDV piping materials are as follows:

| Material | $S_h$(600°F) ksi | $S_A$(1000 cycles) ksi | $0.4(1.2\ S_h + S_A)$ ksi |
|---|---|---|---|
| SA 106 Gr. B, SA 106 Gr. C Carbon steel | 15 | 75 | 37.2 |
| SA 358 304L Stainless steel | 14 | 105 | 48.7 |

Thus, it follows that Class 2 piping in the SDV piping system also satisfies the criteria for not postulating a through-wall leakage crack as stated in BTP MEB 3-1, Position B.2.c(1). The staff, therefore, concludes that no break or through-wall leakage crack need be postulated in the SDV piping.

## 2.2 Fracture Mechanics Evaluation Of SDV Piping Integrity

This section deals with the staff's evaluation of the probabilistic and deterministic fracture mechanics evaluation of the SDV piping integrity provided by GE in NEDO-22209 and the BWROG-8420 to support the conclusion that breaks in the SDV piping system are very unlikely.

In NEDO-22209, the loss of piping integrity in the SDV piping system was calculated based on a consideration of pipe length, scram frequency, and vent and drain valve reliability. Conservative values for the key inputs were selected based on BWR plant data and on generic reliability data. Pipe break probabilities were estimated based on the experience data used in the NUREG-75/014 (formerly WASH-1400), and on a fracture mechanics analysis of the piping system.

The results of the above analyses indicated that the probability of an unisolatable loss of scram system piping integrity for an average plant is $3 \times 10^{-7}$ per plant year. The probability of core damage resulting from a loss of SDV pipe integrity was determined to be approximately $4 \times 10^{-11}$ events per reactor year. This is significantly below the proposed NRC safety goal for core melt events of $10^{-4}$ per plant year. Consequently, GE concluded that the probability of a loss of scram system piping integrity leading to core damage is sufficiently low to preclude the necessity of qualification or design modifications of equipment required to detect and/or mitigate the consequences of such an event.

The staff verified the fracture mechanics equation utilized by GE for the analysis in NEDO-22209 by comparing the influence function parameters in the equation with those used by the staff for pressurized thermal shock analyses of reactor vessels. It was concluded that there was reasonably good agreement. The staff analyses results had been previously found to agree with analyses performed by ORNL. The results reported in NEDO-22209 are also consistent with those obtained by Lawrence Livermore Laboratory in NUREG/CR-3660 for reactor coolant piping. Both reports concluded that on the basis of probabilistic fracture mechanics, the likelihood of pipe breaks in the SDV piping system is low.

As stated earlier, the staff requested the BWROG to perform a deterministic fracture mechanics analysis for the SDV piping system (NRC, letter from D. G. Eisenhut to T. J. Dente), especially for the larger diameter pipes (NRC, notes of meeting held February 23, 1984) to assure that detectable leaks would occur prior to pipe rupture and also to support the probabilistic fracture mechanics conclusions given in NEDO-22209 (refer to Section 1.3 of this report for more specific discussion regarding the request).

In response to the above request, the BWROG performed a generic deterministic fracture mechanics evaluation of the SDV piping (BWROG-8420) for the staff postulated through-wall flaw in the piping to bound the loading conditions, material properties for the system, and associated leak rates using the SDV piping system data provided by the participating utilities. BWROG-8420 indicated that the response to the staff's request relating to the expected radiation field and contact exposure level at the scram system piping should be provided by each of the participating utilities.

The deterministic fracture mechanics procedures used by the BWROG (BWROG-8420) to respond to the staff request are based on linear elastic methods and limit load analyses. This methodology is well documented in the literature and has been benchmarked against flawed pipe experiments. Three areas of uncertainty exist in evaluating the results of the analyses:

1. piping loads,
2. material properties, and
3. accuracy of evaluation methods.

By selecting stresses which bound specific data for all the facilities included in the study (BWROG-8420), the BWROG has addressed the uncertainty of loads. Material property data were also conservatively selected in that the BWROG assumed all materials to be SA 106 Grade B and C which have limiting toughness properties. Actual materials used in scram discharge systems also include stainless steel which is a tougher material.

Limit-load analyses have been used routinely by the staff. A limit-load analysis is based on equating the forces and moments on the area of the pipe containing a real or a postulated flaw to those applied at the end of the pipe. A condition regarding the application of a limit-load analysis to a pipe is that the piping materials must be tough; that is, it will resist crack propagation until the limiting condition -- the limiting load -- is reached and then the pipe is assumed to fail. Most piping materials used in a nuclear facility meet this condition and, in general the applied loads are well below the limit load. This is a simple procedure, compared to more elaborate and sophisticated fracture mechanics methods also being used, and therefore its limitations must be recognized. The ratio of critical through-wall crack length to the postulated crack length suggested by the staff was found by the BWROG to range from 2.45 for a 3/4 inch diameter pipe up to greater than 8 for pipes 8 inches in diameter and larger. Thus, the staff concludes that there is adequate margin to account for analytical uncertainties in the procedures used.

For the reasons stated above, the staff concludes that the deterministic fracture mechanics analyses performed by the BWROG (BWROG-8420) were done in a conservative manner and support the earlier conclusions reached by GE on scram discharge piping system integrity by probabilistic fracture mechanics analysis in NEDO-22209. The staff concludes therefore, that the bounding values for loading conditions and material properties given in the report (BWROG-8420) are reasonable. The staff further concludes that there is reasonable assurance that the staff postulated flaw, should it be initially present in the SDV piping system, will grow negligibly and will not propagate into a break under the staff defined piping loads (refer to Section 1.3 of this SER).

2.3 Leak Detection And Mitigation Capability

This section deals with the staff's evaluation of the leak detection and mitigation capabilities for the SDV piping system discussed in the submittal BWROG-8420.

As stated in Section 2.1 of this report, the staff has concluded that either a break or a through-wall leakage crack in the SDV piping system need not be postulated. Furthermore, the staff has also concluded that even if the staff postulated through-wall flaw is initially present in the SDV piping system, it will not propagate into a break under the staff defined piping loads, and that the bounding values for loading conditions and material properties for such a postulated flaw given in BWROG-8420 are reasonable (see Section 2.2 of this report). The resulting leak rates are low ($\leq$ 3.5 pgm; $\leq$5.3 gpm even conservatively assuming 400 scram cycles for the 40-year plant life time). Therefore, the staff agrees with the BWROG that this small leakage will not pose a threat to the environmental qualification envelope for essential equipment needed for detection of the leak and mitigation of its consequences. The staff's evaluation of the leak detection and mitigation capabilities for the SDV piping system given in the submittal (BWROG-8420) are, therefore, based on the above conclusions.

In its May 10, 1984 submittal (BWROG-8420), the BWROG states that their recommendations relating to leak detection will be adequate for detecting leaks resulting from the postulated flaw in the SDV piping system. They further state that the operator actions specified in normal plant procedure and/or the generic emergency procedure guidelines (EPGs) for BWRs given in NEDO-24934 will be adequate for mitigating adverse consequences that may result from a flaw or even a break in the SDV piping system.

Specifically, the BWROG in their submittal (BWROG-8420) recommend the following relating to leak detection for the SDV piping system:

1. For plants which employ the leak test criteria for Class 1 piping, leak tests and inspections shall be performed once every refueling outage per the criterion for such pipes contained in Section XI of the ASME Code.

2. For plants which employ the leak test criteria for Class 2 piping, leak tests and inspections shall be performed periodically at repeating intervals of 3, 4 and 3 years per the criterion for such pipes contained in the ASME Code, Section XI. Additionally, a post-scram reset walkdown of the SDV piping shall be performed once per refueling cycle as soon as possible but not more than 30 minutes following the scram reset. This walkdown shall be performed specifically to investigate evidence of leakage below the SDV header and instrument volume by visual observation.

The BWROG indicates that the walkdown suggested above would be sufficient to detect appreciable leakage from the system should it occur and would also enhance the leak detection capability for systems that utilize Class 2 piping.

With regard to the mitigation capability, NEDO-24934 includes the EPGs for secondary containment control, and lists the entry conditions. Included among these is secondary containment sump water level being above the normal operating level. Among the objectives of these procedures, is protection of essential equipment needed for shutdown or mitigation or prevention of an accident. The conditions under which these emergency procedures will be utilized are symptomatic of potential accidents. The EPGs encompass instruction for operators for handling problems arising from pipe breaks outside the containment such as an SDV pipe break.

The BWROG submittal (BWROG-8420) addresses mitigation by stating that in the event of a break in the scram discharge piping system, the normal plant procedures will call for a reset of the scram. If, however, the affected system cannot be isolated or the isolation proves ineffective in mitigating temperature or radiation increases, the generic emergency operating procedures will call for rapid depressurization of the reactor to be accomplished by safety valve discharge into the suppression pool. This will reduce the leakage into the reactor building. The submittal also states that the generic emergency operating procedures guidelines (NEDO-24934) specify the operator actions for achieving isolation and reactor depressurization should they be needed to mitigate the leak consequences resulting from the postulated flaw.

Based on review of the above information, the staff concludes that the periodic leak tests, inspection and post-scram reset walkdown of SDV piping recommended by the BWROG (BWROG-8420) provide adequate capability for detection of leakages resulting from the staff postulated through-wall flaw in the SDV piping system. The staff also concludes that normal BWR operating procedures and the applicable EPGs for secondary containment control and dealing with problems that may arise in the secondary containment due to leakage from systems such as the SDV piping system, given in NEDO-24934 are adequate to mitigate the consequences of leakage resulting from the staff postulated through-wall flaw in the SDV piping system.

## 3.0 Conclusion

Based on review of the GE and BWROG submittals regarding SDV piping system integrity for BWR Mark 1 and Mark 2 containment designs and independent analyses of the system integrity, the staff concludes the following:

1. The SDV piping satisfies the criteria for not postulating either a break or a through-wall leakage crack as stated in SRP Section 3.6.2 [NUREG-0800, BTP MEB 3-1, Position B.2.e and B.2.c.(1)] and reiterated in SRP Section 3.6.1 (NUREG-0800, BTP ASB 3-1, Appendix A). Therefore, a break or a through-wall leakage crack need not be postulated in the SDV piping system.

2. Probabilistic fracture mechanics evaluation of the SDV piping system integrity performed conservatively using the BWR plant data and generic reliability data confirms the above conclusion, i.e., the probability for an unisolatable loss of scram system piping integrity is very low (about $3 \times 10^{-7}$ per plant year). The analysis also confirms that the probability of core damage resulting from such a loss of integrity is very low (about $4 \times 10^{-11}$ events per reactor year). A deterministic fracture mechanics evaluation of the staff postulated through-wall flaw in the system performed conservatively supports the conclusion, that is, even if the staff postulated through-wall flaw is initially present in the SDV piping system, it will grow negligibly and will not propagate into a break under the staff defined piping loads. Further, the bounding values for loading conditions, material properties, and leak rates for the SDV piping system, given in the BWROG submittal dealing with the deterministic fracture mechanics evaluation (BWROG-8420) are reasonable.

3. The leakage from the staff postulated through-wall flaw in the SDV piping system will be low enough ($\leq$ 3.5 gpm, $\leq$ 5.3 gpm even conservatively assuming 400 scram cycles for the 40-year plant life time)

that a harsh environment will not occur, thus precluding the need for environmentally qualifying leak detection and mitigation equipment exposed to the leak environment. Thus, the design of the SDV piping system as described in BWROG-8420 satisfies the intent and purpose of the applicable guidelines provided in BTP ASB 3-1 (NUREG-0800).

4. Periodic leak testing, inspections and post-scram reset walkdowns recommended by the BWROG (BWROG-8420), normal BWR operating procedures, and the applicable generic secondary containment control emergency procedure guidelines (EPGs) given in NEDO-24934 are adequate to ensure the detection of a leak resulting from the staff postulated flaw in the SDV piping system and mitigate its consequences. Thus, the leak detection and mitigation capabilities for the SDV piping system meet the intent and purpose of the applicable guidelines provided in BTP ASB 3-1 (NUREG-0800).

In view of the above considerations, the staff concludes that the design of the SDV piping system described in BWROG-8420 regarding its integrity, the method of verification of the integrity of the system, and the leak detection and mitigation capabilities for the system provided in BWROG-8420 and NEDO-24934 satisfy the applicable criteria of SRP Sections 3.6.1 and 3.6.2 (NUREG-0800) and, are, therefore, acceptable. The staff further concludes that the above approach provides sufficient defense in depth to satisfy the concerns identified in NUREG-0803 regarding the postulated SDV pipe break.

## 4.0 References

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