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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.6.1 PLANT DESIGN FOR PROTECTION AGAINST POSTULATED PIPING FAILURES IN FLUID SYSTEMS OUTSIDE CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch (SPLB)

Secondary - None

I. AREAS OF REVIEW

The plant design for protection against piping failures outside containment is reviewed to ~~assure~~ensure[1] that such failures would not cause the loss of needed functions of safety-related systems and to ~~assure~~ensure that the plant could be safely shut down in the event of such failures. The review includes high energy and moderate energy fluid system piping located outside of containment. If such a system penetrates containment (except for the auxiliary feedwater system) the review starts with the first isolation valve outside of containment. The review boundary for auxiliary feedwater systems extends either to the steam generator or to the feedwater (or steam) line, as appropriate. The SPLB reviews the plant design to ~~assure~~ensure conformance with the requirements of General Design ~~Criteria~~ Criterion[2] 4 (GDC 4).[3] The specific areas of review are as follows:

1. SPLB reviews the general layout of high and moderate energy piping systems with respect to the plant arrangement criteria of Section B.1 of Branch Technical Position (BTP) SPLB 3-1, which is attached to this Standard Review Plan (SRP)[4] section. Three

arrangement situations are covered by the criteria and all three may be encountered in a single plant. They are:

a. Arrangements where protection of safety-related plant features is provided by separation of high and moderate energy systems from essential systems and components.

b. Arrangements where protection of safety-related plant features is provided by enclosing either the high and moderate energy systems or the safety-related features in protective structures.

c. Arrangements where neither separation nor protective enclosures are practical and special protective measures are taken to ensure the operability of safety-related features.

Review Interfaces[5]

1. SPLB, coordinates with other review branches as detailed below and reviews design features recommended in Section B.2 of BTP SPLB 3-1 as follows:

   a. The Mechanical Engineering Branch (EMEB) confirms the seismic and quality group classifications of systems and components defined as essential safety-related features in Appendix A of BTP SPLB 3-1, as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2.

   b. SPLB identifies protective structures, piping restraints, and other measures used for protection against pipe breaks outside containment. Review of the specific aspects of these elements recommended in item B.2.b of BTP SPLB 3-1 is done by the ~~Structural and Geosciences Branch (ESGB)~~Civil Engineering and Geosciences Branch (ECGB)[6] and EMEB, as follows:

      (1) ~~ESGB~~ECGB[7] reviews the design of protective structures in connection with the review of other Category I structures under SRP Section 3.8.4.

      (2) EMEB reviews the design of piping restraints and other protective measures in connection with the review of break locations and dynamic effects of piping failures under SRP Section 3.6.2.

   c. SPLB identifies portions of high and moderate energy fluid system piping between containment isolation valves that are subject to the recommendations of item B.2.c of BTP SPLB 3-1. EMEB reviews the design of these portions of piping in connection with the review of break locations and dynamic effects of piping failures under SRP Section 3.6.2.

2. SPLB reviews analyses of postulated piping failures with respect to the guidelines of Section B.3 of BTP SPLB 3-1. The locations and types of failures to be considered and the dynamic effects associated with the failures are reviewed by the EMEB under SRP Section 3.6.2.

   a. SPLB reviews analyses of piping failures in high and moderate energy fluid systems postulated according to the guidelines of B.3.a of BTP SPLB 3-1. SPLB reviews resulting environmental conditions resulting from postulated piping failures.

   b. SPLB reviews the assumptions made in the analyses with regard to:

      (1) The availability of offsite power.

      (2) The failure of a single active component in systems used to mitigate the consequences of the piping failure.

      (3) The special provisions applicable to certain dual purpose systems.

      (4) The use of available systems to mitigate the consequences of the piping failure.

   c. SPLB reviews the effects of postulated failures on the habitability of the control room and access to areas important to safe control of postaccident operations.

   d. SPLB reviews the effects of piping failures in systems not designed to seismic Category I standards on essential systems and components.

   e. SPLB reviews the environmental effects of pipe rupture, such as temperature, humidity, and spray-wetting with respect to the functional performance of essential electrical equipment and instrumentation as part of its primary review responsibility for SRP Section 3.11.

In addition, the SPLB will coordinate other branches evaluations that interface with the overall review of the system as follows:

1. The Reactor Systems Branch (SRXB) reviews the design of systems and components that interface with the reactor coolant system with regard to prevention or mitigation of intersystem loss-of-coolant accidents (ISLOCA) as part of its primary review responsibility for SRP Section 3.12 (proposed).[8]

2. If an applicant proposes to use leak-before-break technology to exclude the dynamic effects of postulated pipe ruptures from the design basis of plant structures, systems and components, the Materials and Chemical Engineering Branch (EMCB) will review the applicant's design and analyses as part of its primary review responsibility for SRP Section 3.6.3 (later).[9]

3. The ~~Materials Engineering Branch (EMTB)~~Civil Engineering and Geosciences Branch (ECGB)[10] reviews inservice inspection aspects of piping within protective structures or guard pipes, between containment isolation valves, as part of its primary review responsibility for SRP Section 6.6.

For those areas of review identified ~~above~~ as part of the primary ~~review~~ responsibility of other branches, the acceptance criteria ~~necessary for the review~~ and ~~their~~ methods of application are contained in the referenced SRP section ~~of the corresponding primary branch~~.[11]

II. ACCEPTANCE CRITERIA

Acceptability of the plant design for protection against postulated piping breaks outside containment, as described in the applicant's safety analysis report (SAR), will be based on ~~General Design Criterion~~GDC[12] 4, as it relates to structures, systems and components important to safety being designed to accommodate the dynamic effects of postulated pipe rupture, including the effects of pipe whipping and discharging fluids. Acceptance is based on conformance to Branch Technical Position SPLB 3-1, attached to this SRP section.

Technical Rationale[13]

The technical rationale for application of these acceptance criteria is discussed in the following paragraphs:[14]

Compliance with GDC 4 requires that structures, systems, and components important to safety shall be designed to accommodate the effects of, and be compatible with, environmental conditions associated with normal operations, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects (including those of missiles, pipe whipping, and discharge fluids) that may result from equipment failures and from events outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for piping.

GDC 4 applies to this SRP section because the reviewer verifies that a suitable and controlled operating environment will be provided for structures, systems, and components during normal operations, during anticipated operational occurrences, and during and after postulated accidents, including loss-of-coolant accidents. In the case of SRP Section 3.6.1, these requirements are imposed to ensure (a) that piping failures in fluid systems outside the containment will not cause the loss of needed function in safety-related systems and (b) that the plant could be safely shut down in the event of such a failure.

Meeting the requirements of GDC 4 provides assurance that structures, systems, and components will not fail to operate as designed, thereby providing protection against loss of core cooling and loss of containment integrity.[15]

III. REVIEW PROCEDURES

All the systems of concern in this section have been reviewed under other SRP sections with respect to design functions for normal operation and for the prevention or mitigation of accidents. The review under this SRP section does not deal with individual system design requirements necessary to ~~assure~~ensure that each system performs as intended, but rather considers the protection necessary to ~~assure~~ensure the operation of such systems in the event of nearby piping failures. The reviewer will select and emphasize material in the review, as may be appropriate for a particular case.

1. SPLB reviews the information presented in the SAR identifying all high and moderate energy fluid systems, and verifies by comparison with individual system temperatures and pressures that they have been correctly identified. The reviewer will then, by reviewing system descriptions of the high and moderate energy piping runs, and by reviewing the appropriate system arrangement and piping drawings, examine the plant arrangement measures that were taken to ~~assure~~ensure protection from the effects of postulated pipe breaks of high energy systems, or of leakage cracks for moderate energy systems. The reviewer will determine from the SAR that the following means, either by themselves or in combination, have been used by the applicant to achieve this protection:

    a. High and moderate energy fluid systems are separated from essential systems and components, as defined in Appendix A to BTP SPLB 3-1. The reviewer inspects plant arrangement drawings and other information to verify that this is the case.

    b. High and moderate energy fluid systems, or portions thereof, are enclosed within structures or compartments designed to protect nearby essential systems or components, or the essential systems and components are enclosed in protective structures. The reviewer traces the routing of the systems identified in the SAR as high or moderate energy systems on appropriate plant arrangement drawings, locates the postulated break locations specified in the applicant's analyses, and determines all locations where the effects from the breaks or leaks interface with safety-related equipment. The reviewer then determines that at these locations, enclosures have been provided that protect the safety-related equipment. Where questions as to break locations arise, the reviewer consults the EMEB for a determination on the proper locations.

    c. For cases where neither physical separation nor protective enclosures are considered practical by the applicant, the SPLB will review the SAR information to verify the following:

        (1) The reasons for which the applicant judged both physical separation and system enclosure to be impractical as means of protection are consistent with item B.1.c of BTP SPLB 3-1.

        (2) Redundant design features or additional protection have been provided in these situations and are such that failure modes and effects analyses for all failure situations show that the performance of safety features will be

assuredensured, assuming a single active failure in any required system. These analyses are done under the criteria and assumptions of item B.3 of BTP SPLB 3-1. Special measures taken to provide additional protection are reviewed on an individual case basis, with assistance from the other review branches as needed.

2. SPLB reviews the information presented in the SAR that identifies the principal design features. The reviewer performs his the[16] evaluation by comparing the design basis information given in the SAR with that described in item B.2 of BTP SPLB 3-1. By this comparison of individual design features, the reviewer verifies as follows that the necessary measures have been provided by the applicant in his applicant's[17] design.

   a. SPLB, with assistance from ESGBECGB[18] and EMEB, reviews the design features provided for protective structures or compartments, fluid system piping restraints, and other protective measures as described in item B.2.b of BTP SPLB 3-1. The reviewer compares the design features and bases given in the SAR with the stated item in BTP SPLB 3-1. The comparative review may include the use of plant arrangement and layout drawings as necessary to clarify the design intentions and implementation. In the majority of case reviews, SAR statements and drawings indicating that the design meets the intent of the acceptance criteria are accepted. However, there may be cases where engineering judgment and independent staff analyses are needed to verify the capability of structures and components to withstand the dynamic pressure and mechanical effects of a pipe rupture.

   b. SPLB reviews the SAR information, as supplemented by engineering sketches or drawings where necessary, to determine that fluid system piping between containment isolation valves conforms to item B.2.c of BTP SPLB 3-1. This includes piping penetrations between single and dual barrier containments that may have enclosing protective structures. The review is mainly performed on a comparative basis by SPLB. EMEB reviews these piping details to verify the design limits, break locations, and dynamic effects, in accordance with BTP EMEB 3-1.

3. SPLB reviews the results of the applicant's evaluation of the consequences of postulated piping failures of high and moderate energy fluid piping systems. The type and location of each postulated piping failure (i.e., longitudinal or circumferential) in either a high or moderate energy system will be reviewed by EMEB on the basis of BTP EMEB 3-1. The review by SPLB will be based upon the information provided by applicants in the SAR concerning the effects of postulated failures on essential equipment and the ability of the plant to be safely shut down, as described in item B.3 of BTP SPLB 3-1.

The reviewer verifies that the applicant's evaluation has properly considered the following points, and in certain cases, as necessary, performs an independent evaluation especially with regard to single failure analyses.

a. SPLB reviews the applicant's plant arrangements and design features using layout drawings to ~~assure~~ensure that all potentially affected essential systems and components have been considered with respect to the effects of an assumed pipe break.

b. SPLB reviews the effects of postulated piping failures as determined from the information given in the SAR. The reviewer will confirm the results of the applicant's evaluations by performing a comparative, but abbreviated as appropriate, failure modes and effects analysis that includes the considerations given in item B.3.d of BTP SPLB 3-1 for the following effects:

   (1) The availability of offsite power.

   (2) The effects of a single active component failure in systems necessary to mitigate consequences of the postulated piping break.

   (3) Permissible exclusions to (2) above based upon the provision given in item B.3.b(3) of BTP SPLB 3-1 for certain dual purpose moderate energy systems.

   (4) The considerations involved in to the selection of available systems to mitigate the consequences of the piping failure.

c. The reviewer will verify from a review of arrangement drawings that control room habitability or access to necessary surrounding areas is not jeopardized as a consequence of the postulated piping failure.

d. SPLB evaluates the applicant's analysis of the postulated failure of nonseismic Category I piping systems by performing a failure modes and effects analysis using SAR information and engineering sketches as necessary.

4. Systems defined in Appendix A to BTP SPLB 3-1 as "essential systems" are those that are needed to shut down the reactor and mitigate the consequences of the pipe break for a given postulated piping break. However, depending upon the type and location of the postulated pipe break, certain safety equipment may not be classified as "essential" for that particular event (e.g., emergency power system or high and low pressure core spray systems). On the other hand, some safety equipment will be "essential" for almost all cases (e.g., service water to ultimate heat sink). Table 3.6.1-1 is a list of those essential systems generally in the latter category.

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[19]

TABLE 3.6.1-1

SYSTEMS USUALLY REQUIRED FOR SAFE SHUTDOWN

PWR	BWR
Service Water System	Service Water System
Auxiliary Feedwater System	Reactor Coolant Injection System
Volume Control System	Automatic Depressurization System
Decay Heat Removal System	Residual Heat Removal System
Component Cooling Water System	Component Cooling Water System (if provided)

Table 3.6.1-2 is a listing of systems typically classified as either high or moderate energy systems that are located outside the primary containment in pressurized water reactor (PWR) and boiling water reactor (BWR) plants.

TABLE 3.6.1-2

TYPICAL HIGH ENERGY SYSTEMS OUTSIDE CONTAINMENT

PWR	BWR
Main Steam Line System	Main Steam Line System
Main Feedwater Line System	Main Feedwater Line System
Auxiliary Feedwater System	High Pressure Core Spray System
Volume Control System	Process Sampling System
Process Sampling System	Condensate System
Condensate System	Reactor Cleanup System

Steam Generator Blowdown Line	Standby Liquid Control System

TYPICAL MODERATE ENERGY SYSTEMS OUTSIDE CONTAINMENT

PWR	BWR
Service Water System	Service Water System
Decay Heat Removal System (outside of reactor coolant pressure boundary)	Residual Heat Removal System (outside of reactor coolant pressure boundary)
Circulating Water System	Circulating Water System
Fire Protection System	Fire Protection System
Component Cooling Water System	Component Cooling Water System

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and ~~his~~ that the[20] review supports conclusions of the following type, to be included in the staff's safety evaluation report (SER):[21]

> The review of the plant design for protection against postulated piping failures outside containment included all high and moderate energy piping systems located outside containment. The review of these high and moderate energy systems for the ________ plant included layout drawings, piping and instrumentation diagrams, and descriptive information.
>
> The staff concludes that the facility design for protection against postulated piping failures outside containment is acceptable and meets the requirements of General Design Criterion 4 with respect to accommodating the effects of postulated pipe ruptures. The applicant has met the requirement of General Design Criterion 4 with respect to postulated pipe ruptures by conforming to Branch Technical Position SPLB 3-1.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[22]

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[23] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[24]

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced Branch Technical Positions.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

2. Branch Technical Position SPLB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to this SRP section.

3. Branch Technical Position EMEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," attached to Standard Review Plan Section 3.6.2.

BRANCH TECHNICAL POSITION SPLB 3-1
~~(FORMERLY BTP ASB 3-1)~~[25]

PROTECTION AGAINST POSTULATED PIPING FAILURES IN
FLUID SYSTEMS OUTSIDE CONTAINMENT

A. BACKGROUND

General Design Criterion 4, ~~"Environmental and Missile Design Bases,"~~"Environmental and Dynamic Effects Design Bases,"[26] of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," requires that systems and components important to safety "...shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit." Guidance on acceptable design approaches to meet General Design Criterion 4 for existing plants and for plants for which applications for construction permits were then under review was provided in letters to applicants and licensees from A. Giambusso, Deputy Director of Licensing for Reactor Projects, most of which were dated in December 1972. The guidance document from these letters is attached as Appendix B to this position. Similar interim guidance for new plants was provided in a letter to applicants, prospective applicants, reactor vendors, and architect-engineers from J. F. O'Leary, Director of Licensing, dated July 12, 1973. This document is attached as Appendix C to this Branch Technical Position.

Reviews of nuclear power plant designs have indicated that the functional or structural integrity of systems and components required for safe shutdown of the reactor and maintenance of cold shutdown conditions could be endangered by fluid system piping failures at locations outside containment. The staff has evolved an acceptable approach for the design, including the arrangement, of fluid systems located outside of containment to ~~assure~~ensure[27] that the plant can be safely shut down in the event of piping failures outside containment. This approach is set forth in this position and in the companion branch technical position BTP EMEB 3-1 attached to SRP Section 3.6.2.

It is the intent of this design approach that postulated piping failures in fluid systems should not cause a loss of function of essential safety-related systems and that nuclear plants should be able to withstand postulated failures of any fluid system piping outside containment, taking into account the direct results of such failure and the further failure of any single active component, with acceptable offsite consequences.

The detailed provisions of the position below and of BTP EMEB 3-1 are intended to implement this intent with due consideration of the special nature of certain dual purpose systems and the need to define and to limit to a finite number the types and locations of piping failures to be analyzed. Although various measures for the protection of safety-related systems and components are outlined in this position, the preferred method of protection is based upon separation and isolation by plant arrangement.

Past applications for CP & OL licenses contained plant layouts where safety-related equipment or structures were located near the main steam and feedwater high energy lines on the basis of utilization of the "break exclusion" design basis in these lines. In consideration of the large magnitude of potential energy stored in these (main steam and feed) systems during normal plant operation, BTP SPLB 3-1 is intended to give clear guidance on acceptable methods for protecting essential equipment from the effects of postulated failures in these systems.

B. BRANCH TECHNICAL POSITION

1. Plant Arrangement

Protection of essential systems and components[28] against postulated piping failures in high or moderate energy fluid systems that operate during normal plant conditions and that are located outside of containment, should be provided by items a, b, or c below in order of their preference.

a. Plant arrangements should separate fluid system piping from essential systems and components. Separation should be achieved by plant physical layouts that provide sufficient distances between essential systems and components and fluid system piping such that the full dynamic effects of any postulated piping failure therein (e.g., pipe whip, jet impingement, and the environmental conditions resulting from the escape of contained fluids as appropriate ~~to~~from[29] high or moderate energy fluid system piping) cannot impair the integrity or operability of essential systems and components.

   (1) Even though portions of the main steam and feedwater lines meet the break exclusion requirements of item B.1.b of BTP EMEB 3-1, they should be separated from essential equipment. Designers are cautioned to avoid concentrating essential equipment in the break exclusion zone. Essential equipment must be protected from the environmental effects of an assumed nonmechanistic longitudinal break of the main steam and feedwater lines. Each assumed nonmechanistic longitudinal break should have a cross sectional area of at least one square foot and should be postulated to occur at a location that has the greatest effect on essential equipment.

   (2) The main steam and feedwater lines should not be routed around or in the vicinity of the control room.

b. Fluid system piping or portions thereof not satisfying the provisions of item B.1.a should be enclosed within structures or compartments designed to protect nearby essential systems and components. Alternatively, essential systems and components may be enclosed within structures or compartments designed to withstand the effects of postulated piping failures in nearby fluid systems.

c. Plant arrangements or system features that do not satisfy the provisions of either item B.1.a or item B.1.b should be limited to those for which the above provisions are impractical because of the stage of design or construction of the plant; because the plant design is based upon that of an earlier plant accepted by the staff as a base plant under the Commission's standardization and replication policy; or for other substantive reasons such as particular design features of the fluid systems. Such cases may arise, for example, (1) at interconnections between fluid systems and essential systems and components, or (2) in fluid systems having dual functions (i.e., required to operate during normal plant conditions as well as to shut down the reactor). In these cases, redundant design features that are separated or otherwise protected from postulated piping failures, or additional protection, should be provided so that the effects of postulated piping failures are shown by the analyses and guidelines of Section B.3 to be acceptable. Additional protection may be provided by restraints and barriers or by designing or testing essential systems and components to withstand the effects associated with postulated piping failures.

If a case should arise as a result of overriding engineering considerations, where adequate separation by physical distance or adequate separation by a combination of distance and barriers cannot be reasonably attained, and so justified to the staff, restraints may be used to assist in obtaining a finding of adequate separation by distance or barriers when designed as follows:

(1) The use of a restraint should not affect the responses of the piping systems when subjected to the loads resulting from normal and upset plant and system operating conditions.

(a) Care should be exercised to ensure that the system stresses due to normal and upset transients, thermal growth, and inertial effects and differential anchor motions associated with seismic events are not adversely affected by the restraints.

(b) A program should be developed to ensure that the system stresses due to long term changes in the system and its supports and restraints, such as due to pipe relaxation and differential settling, will not be adversely affected by the restraints.

(c) Details of the methods used to obtain these assurances should be submitted to the staff for review.

(2) The restraint and its supporting structures should be designed so that they will not prevent the inservice inspection of any pipe welds.

2. Design Features

a. Essential systems and components should be designed to meet the seismic design requirements of Regulatory Guide 1.29.

b. Protective structures or compartments, fluid system piping restraints, and other protective measures should be designed in accordance with the following:

(1) Protective structures or compartments needed to implement Section B.1 should be designed to seismic Category I requirements. The protective structures should be designed to withstand the effects of a postulated piping failure (i.e., pipe whip, jet impingement, pressurization of compartments, water spray, and flooding, as appropriate) in combination with loadings associated with the ~~operating basis earthquake and safe shutdown~~design basis earthquake(s)[30] within the respective design load limits for structures. Piping restraints, if used, may be taken into account to limit effects of the postulated piping failure.

(2) High energy fluid system piping restraints and protective measures should be designed such that a postulated break in one pipe cannot, in turn, lead to rupture of other nearby pipes or components if the secondary rupture could result in consequences that would be considered unacceptable for the initial postulated break. An unrestrained whipping pipe should be considered capable of rendering damage as defined in Subsection III.2. of SRP Section 3.6.

c. Fluid system piping in containment penetration areas should be designed to meet the break exclusion provisions contained in item B.1.b of BTP EMEB 3-1.

d. Piping classification as required by Regulatory Guide 1.26 should be maintained without change until beyond the outboard restraint. If the restraint is located at the isolation valve, a classification change at the valve interface is acceptable.

3. Analyses and Effects of Postulated Piping Failures

a. To show that the plant arrangement and design features provide the necessary protection of essential systems and components, piping failures should be postulated in accordance with BTP EMEB 3-1, attached to SRP Section 3.6.2. In applying the provisions of BTP EMEB 3-1, each longitudinal or circumferential break in high energy fluid system piping or leakage crack in moderate energy fluid system piping should be considered separately as a single postulated initial event occurring during normal plant conditions. An analysis should be made of the effects of each such event, taking into account the provisions of BTP EMEB 3-1 and of the system and component operability considerations of item B.3.b. below. The effects of each postulated piping failure should be shown to result in offsite consequences within the guidelines of 10 CFR Part 100 and to meet the provisions of items B.3.c and d below.

b. In analyzing the effects of postulated piping failures, the following assumptions should be made with regard to the operability of systems and components:

(1) Offsite power should be assumed to be unavailable if a trip of the turbine-generator system or reactor protection system is a direct consequence of the postulated piping failure.

(2) A single active component failure should be assumed in systems used to mitigate consequences of the postulated piping failure and to shut down the reactor, except as noted in item B.3.b(3) below. The single active component failure is assumed to occur in addition to the postulated piping failure and any direct consequences of the piping failure, such as unit trip and loss of offsite power.

(3) Where the postulated piping failure is assumed to occur in one of two or more redundant trains of a dual-purpose moderate-energy essential system, i.e., one required to operate during normal plant conditions as well as to shut down the reactor and mitigate the consequences of the postulated piping failure, single active failures of components in the other train or trains of that system or other systems necessary to mitigate the consequences of the piping failure and shut down the reactor, need not be assumed provided the systems are designed to seismic Category I standards, are powered from both offsite and onsite sources, and are constructed, operated, and inspected to quality assurance, testing, and inservice inspection standards appropriate for nuclear safety systems. Examples of systems that may, in some plant designs, qualify as dual-purpose essential systems are service water systems, component cooling systems, and residual heat removal systems.

(4) All available systems, including those actuated by operator actions, may be employed to mitigate the consequences of a postulated piping failure. In judging the availability of systems, account should be taken of the postulated failure and its direct consequences such as unit trip and loss of offsite power, and of the assumed single active component failure and its direct consequences. The feasibility of carrying out operator actions should be judged on the basis of ample time and adequate access to equipment being available for the proposed actions.

c. The effects of a postulated piping failure, including environmental conditions resulting from the escape of contained fluids, should not preclude habitability of the control room or access to surrounding areas important to the safe control of reactor operations needed to cope with the consequences of the piping failure.

d. The functional capability of essential systems and components should be maintained after a failure of piping not designed to seismic Category I standards, assuming a concurrent single active failure.

e. The considerations related to the leak-before-break approach should conform with the provisions of SRP Section 3.6.3 (later).[31]

~~4. Implementation~~

~~a. Designs of plants for which construction permit applications are tendered after July 1, 1975 should conform to the provisions of this position.~~

b. ~~Designs of plants for which construction permit applications are tendered after July 1, 1973 and before July 1, 1975 should conform to the provisions of either (a) the letter of July 12, 1973 from J. F. O'Leary, Appendix C to this position, or (b) this position, at the option of the applicants.~~

c. ~~Designs of plants for which construction permit applications were tendered before July 1, 1973 and operating licenses are issued after July 1, 1975 should follow the guidance provided in the December 1972 letter from A. Giambusso, Appendix B to this position and provide analyses of moderate energy lines made in conformance with Section B.3 of this position, as part of the operating license application for these plants to demonstrate that acceptable protection against the effects of piping failures outside containment has been provided. Alternately, this position may be used in its entirety as an acceptable basis for this finding.~~

~~For plants in this category for which construction permits are not issued as of February 1, 1975, a commitment by the applicant to either (a) follow the guidance of Appendix B and submit Section B.3 analyses of moderate energy lines with the plant final safety analysis report (FSAR), or (b) conform the plant design to the provisions of this position, should provide an acceptable basis for issuance of the construction permit with regard to effects of piping failures outside containment.~~

d. ~~Designs of plants for which operating licenses are issued before July 1, 1975 are considered acceptable with regard to effects of piping failures outside containment on the basis of the analyses made and measures taken by applicants and licensees in response to the December 1972 letter from A. Giambusso, and the staff review and acceptance of these analyses and measures.~~

~~For plants in this category for which the staff review and acceptance of protection against the effects of piping failures outside containment is not substantially complete as of February 1, 1975, a commitment by the applicant to carry out analyses according to Section B.3 of this position, to submit them for staff review, and to carry out any system modifications found necessary before extended operation of the plant at power levels above one-half the license power level, should provide an acceptable basis for issuance of the operating license.~~[32]

C. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

2. Regulatory Guide 1.29, "Seismic Design Classification."

3. Letter from A. Giambusso, Deputy Director for Reactor Projects, Directorate of Licensing, to applicants and licensees, December 1972, and attachment entitled "General Information Required for Consideration of the Effects of a Piping System Break Outside Containment." The corrected attachment is Appendix B to this position.

4. Letter from J. F. O'Leary, Director of Licensing, to applicants, reactor vendors, and architect-engineers, July 12, 1972, and attachment entitled "Criteria for Determination of Postulated Break and Leakage Locations in High and Moderate Energy Fluid Piping Systems Outside of Containment Structures." The letter and attachment is Appendix C to this position.

APPENDIX A
BRANCH TECHNICAL POSITION SPLB 3-1
DEFINITIONS

Essential Systems and Components. Systems and components required to shut down the reactor and mitigate the consequences of a postulated piping failure, without offsite power.

Fluid Systems. High and moderate energy fluid systems that are subject to the postulation of piping failures outside containment against which protection of essential systems and components is needed.

High Energy Fluid Systems. Fluid systems that, during normal plant conditions are either in operation or maintained pressurized under conditions where either or both of the following are met:

a. Maximum operating temperature exceeds 95 °C (200 °F),[33] or

b. Maximum operating pressure exceeds 1900 kPa (275 psig).[34]

Moderate Energy Fluid Systems. Fluid systems that, during normal plant conditions, are either in operation or maintained pressurized (above atmospheric pressure) under conditions where both of the following are met:

a. Maximum operating temperature is 95 °C (200 °F)[35] or less, and

b. Maximum operating pressure is 1900 kPa (275 psig)[36] or less

Normal Plant Conditions. Plant operating conditions during reactor startup, operation at power, hot standby, or reactor cooldown to cold shutdown condition.

Upset Plant Conditions. Plant operating conditions during system transients that may occur with moderate frequency during plant service life and are anticipated operational occurrences, but not during system testing.

Postulated Piping Failures. Longitudinal and circumferential breaks in high energy fluid system piping and through-wall leakage cracks in moderate energy fluid system piping postulated according to the provisions of BTP EMEB 3-1, attached to SRP Section 3.6.2.

Single Active Component Failure. Malfunction or loss of function of a component of electrical or fluid systems. The failure of an active component of a fluid system is considered to be a loss of component function as a result of mechanical, hydraulic, pneumatic, or electrical malfunction, but not the loss of component structural integrity. The direct consequences of a single active component failure are considered to be part of the single failure.

APPENDIX B
BRANCH TECHNICAL POSITION SPLB 3-1

This appendix consists of the attachment to the letters sent by A. Giambusso, Deputy Director for Reactor Projects, Directorate of Licensing, in December 1972 to applicants and licensees on the subject of postulated piping failures outside containment. The attachment provided guidance on measures to be taken and on information to be submitted. An errata sheet for the attachment was sent in January 1973 to recipients of the original letters. The attachment as given here has been corrected for the errata.

General Information Required for Consideration of the Effects of a Piping System Break Outside Containment

The following is a general list of information required for ~~AEC~~NRC[37] review of the effects of a piping system break outside containment, including the double-ended rupture of the largest pipe in the main steam and feedwater systems, and for ~~AEC~~NRC[38] review of any proposed design changes that may be found necessary. Since piping layouts are substantially different from plant to plant, applicants and licensees should determine on an individual plant basis the applicability of each of the following items for inclusion in their submittals.

1. The systems (or portions of systems) for which protection against pipe whip is required should be identified. Protection from pipe whip need not be provided if any of the following conditions will exist:

   (a) Both of the following piping system conditions are met:

      (1) the service temperature is less than 95 °C (200 °F);[39] and

      (2) the design pressure is 1900 kPa (275 psi)[40] or less; or

   (b) The piping is physically separated (or isolated) from structures, systems, or components important to safety by protective barriers, or restrained from whipping by plant design features, such as concrete encasement; or

   (c) Following a single break, the unrestrained pipe movement of either end of the ruptured pipe in any possible direction about a plastic hinge formed at the nearest pipe whip restraint cannot impact any structure, system, or component important to safety; or

   (d) The internal energy level[a*] associated with the whipping pipe can be demonstrated to be insufficient to impair the safety function of any structure, system or component to an unacceptable level.

*~~Footnotes~~Alphabetical superscripts[41] are collected at the end of this appendix.

2. Design basis break locations should be selected in accordance with the following pipe whip protection criteria: however, where pipes carrying high energy fluids are routed in the vicinity of structures and systems necessary for safe shutdown of the nuclear plant,

supplemental protection of those structures and systems shall be provided to cope with the environmental effects (including the effects of jet impingement) of a single postulated open crack at the most adverse location(s) with regard to those essential structures and systems, the length of the crack being chosen not to exceed the critical crack size. The critical crack size is taken to be 1/2 the pipe diameter in length and 1/2 the wall thickness in width.

The criteria used to determine the design basis piping break locations in the piping systems should be equivalent to the following:

(a) ASME Section III Code Class I piping[b] breaks should be postulated to occur at the following locations in each piping run exceeds 2.0 S_m derived from the piping fatigue analysis and based on all normal, upset, and testing plant conditions exceeds 0.1; and

(4) At intermediate locations in addition to those determined by (1) and (2) above, selected on a reasonable basis as necessary to provide protection. As a minimum, there should be two intermediate locations for each piping run or branch run.

(b) ASME Section III Code Class 2 and 3 piping breaks should be postulated to occur at the following locations in each piping run or branch run:

(1) The terminal ends;

(2) Any intermediate locations between terminal ends where either the circumferential or longitudinal stresses derived on an elastically calculated basis under the loadings associated with seismic events and operational plant conditions exceed 0.8 (S_h[g]+ S_A[h] or the expansion stresses exceed 0.8 S_A; and

(3) Intermediate locations in addition to these determined by (2) above, selected on a reasonable basis as necessary to provide protection. As a minimum, there should be two intermediate locations for each piping run or branch run.

3. The criteria used to determine the pipe break orientation at the break locations as specified under (2) above should be equivalent to the following:

(a) Longitudinal[i] breaks in piping runs and branch runs, 10 cm (4 inches,[42] nominal pipe size and larger, and/or

(b) Circumferential[j] breaks in piping runs and branch runs exceeding 2.5 cm (1 inch)[43] nominal pipe size.

4. A summary should be provided of the dynamic analyses applicable to the design of Category I piping and associated supports which determine the resulting loadings as a result of a postulated pipe break, including:

   (a) The locations and number of design basis breaks on which the dynamic analyses are based.

   (b) The postulated rupture orientation, such as a circumferential and/or longitudinal break(s), for each postulated design basis break location.

   (c) A description of the forcing functions used for the pipe whip dynamic analyses, including the direction, rise time, magnitude, duration, and initial conditions that adequately represent the jet stream dynamics and the system pressure difference.

   (d) Diagrams of mathematical models used for the dynamic analysis.

   (e) A summary of the analyses which demonstrates that unrestrained motion of ruptured lines will not damage to an unacceptable degree, structures, systems, or components important to safety, such as the control room.

5. A description should be provided of the measures, as applicable, to protect against pipe whip, blowdown jet and reactive forces, including:

   (a) Pipe restraint design to prevent whip impact;

   (b) Protective provisions for structures, systems, and components required for safety against pipe whip and blowdown jet and reactive forces;

   (c) Separation of redundant features;

   (d) Provisions to separate physically piping and other components of redundant features; and

   (e) A description of the typical pipe whip restraints and a summary of number and location of all restraints in each system.

6. The procedures that will be used to evaluate the structural adequacy of Category I structures and to design new seismic Category I structures should be provided, including:

   (a) The method of evaluating stresses, e.g., the working stress method and/or the ultimate strength method that will be used;

   (b) The allowable design stresses and/or strains; and

   (c) The load factors and the load combinations.

7. The structural design loads, including the pressure and temperature transients, the dead, live and equipment loads and the pipe and equipment static, thermal, and dynamic reactions should be provided.

8. Seismic Category I structural elements such as floors, interior walls, exterior walls, building penetrations and the buildings as a whole should be analyzed for eventual reversal of loads due to the postulated accident.

9. If new openings are to be provided in existing structures, the capabilities of the modified structures to carry the design loads should be demonstrated.

10. Verification that failure of any structure, including nonseismic Category I structures, caused by the accident, will not cause failure of any other structure in a manner to adversely affect:

    (a) Mitigation of the consequences of the accidents; and

    (b) Capability to bring the unit(s) to a cold shutdown condition.

11. Verification that rupture of a pipe carrying high energy fluid will not directly or indirectly result in:

    (a) Loss of required redundancy in any portion of the protection system (as defined in ~~IEEE-279~~IEEE 603-1980[44]), Class IE electric system (as defined in IEEE-308[45]), engineered safety feature equipment, cable penetrations, or their interconnecting cables required to mitigate the consequences of that accident and place the reactor(s) in a cold shutdown condition; or

    (b) Environmentally induced failures caused by a leak or rupture of the pipe which would not of itself result in protective action but does disable protection functions. In this regard, a loss of redundancy is permitted; but a loss of function is not permitted. For such situations, plant shutdown is required.

12. Assurance should be provided that the control room will be habitable and its equipment functional after a steam line or feedwater line break or that the capability for shutdown and cooldown on the unit(s) will be available in another habitable area.

13. Environmental qualification should be demonstrated by test for that electrical equipment required to function in the steam-air environment resulting from a high energy line break. The information required for our review should include the following:

    (a) Identification of all electrical equipment necessary to meet requirements of (11) above. The time after the accident in which they are required to operate should be given.

    (b) The test conditions and the results of test data showing that the systems will perform their intended function in the environment resulting from the postulated accident and time interval of the accident. Environmental conditions used for the tests should be selected from a conservative evaluation of accident conditions.

(c) The results of a study of steam systems identifying locations where barriers will be required to prevent steam jet impingement from disabling a protection system. The design criteria for the barriers should be stated and the capability of the equipment to survive within the protected environment should be described.

(d) An evaluation of the capability for safety-related electrical equipment in the control room to function in the environment that may exist following a pipe break accident should be provided. Environmental conditions used for the evaluation should be selected from conservative calculations of accident conditions.

(e) An evaluation to ~~assure~~ensure that the onsite power distribution system and onsite sources (diesels and batteries) will remain operable throughout the event.

14. Design diagrams and drawings of the steam and feedwater lines, including branch lines showing the routing from containment to the turbine building should be provided. The drawings should show elevations and include the location relative to the piping runs of safety-related equipment, including ventilation equipment, intakes, and ducts.

15. A discussion should be provided of the potential for flooding of safety-related equipment in the event of failure of a feedwater line or any other line carrying high energy fluid.

16. A description should be provided of the quality control and inspection programs that will be required or have been utilized for piping systems outside containment.

17. If leak detection equipment is to be used in the proposed modifications, a discussion of its capabilities should be provided.

18. A summary should be provided of the emergency procedures that would be followed after a pipe break accident, including the automatic and manual operations required to place the reactor unit(s) in a cold shutdown condition. The estimated times following the accident for all equipment and personnel operational actions should be included in the procedure summary.

19. A description should be provided of the seismic and quality classification of the high energy fluid piping systems, including the steam and feedwater piping that runs near structures, systems, or components important to safety.

20. A description should be provided of the assumptions, methods, and results of analyses, including steam generator blowdown, used to calculate the pressure and temperature transients in compartments, pipe tunnels, intermediate buildings, and the turbine building following a pipe rupture in these areas. The equipment assumed to function in the analyses should be identified and the capability of systems required to function to meet a single active component failure should be described.

21. A description should be provided of the methods or analyses performed to demonstrate that there will be no adverse effects on the primary and/or secondary containment structures due to a pipe rupture outside these structures.

~~1~~a. The internal fluid energy level associated with the pipe break reaction may take into account any line restrictions (e.g., flow limiter) between the pressure source and break location, and the effects of either single-ended or double-ended flow conditions, as applicable. The energy level in a whipping pipe may be considered as insufficient to rupture an impacted pipe of equal or greater nominal pipe size and equal or heavier wall thickness.

~~2~~b. Piping is a pressure retaining component consisting of straight or curved pipe and pipe fittings (e.g., elbows, tees, and reducers).

~~3~~c. A piping run interconnects components such as pressure vessels, pumps, and rigidly fixed valves that may act to restrain pipe movement beyond that required for design thermal displacement. A branch run differs from a piping run only in that it originates at a piping intersection, as a branch of the main pipe run.

~~4~~d. Operational plant conditions include normal reactor operation, upset conditions (e.g., anticipated operational occurrences) and testing conditions.

~~5~~e. S_m is the design stress intensity as specified in Section III[46] of the ASME Boiler and Pressure Vessel Code, "Nuclear Plant Components."

~~6~~f. ~~S_A~~ U[47] is the cumulative usage factor as specified in Section III[48] of the ASME Boiler and Pressure Vessel Code, Nuclear Power Plant Components."

~~7~~g. S_h is the stress calculated by the rules of NC-3600 and ND-3600 for Class 2 and 3 components, respectively, of the ASME Code Section III[49] Winter 1972 Addenda. S_A is the allowable stress range for expansion stress calculated by the rules of NC-3600 of the ASME Code, Section III,[50] or the USA Standard Code for Pressure Piping, ANSI B31.1.0-1967.[51]

~~8~~h. Longitudinal breaks are parallel to the pipe axis and oriented at any point around the pipe circumference. The break area is equal to the effective cross-sectional flow area upstream of the break location. Dynamic forces resulting from such breaks are assumed to cause lateral pipe movements in the direction normal to the pipe axis.

~~9~~j. Circumferential breaks are perpendicular to the pipe axis, and the break area is equivalent to the internal cross-sectional area of the ruptured pipe. Dynamic forces resulting from such breaks are assumed to separate the piping axially, and cause whipping in any direction normal to the pipe axis.

APPENDIX C
BRANCH TECHNICAL POSITION SPLB 3-1

This appendix consists of the letter and attachment sent by J. F. O'Leary, Director of Licensing, to applicants, reactor vendors, and architect-engineers on the subject of postulated piping failures outside containment. The letter was dated July 12, 1973.

Late last year, the Atomic Energy Commission's Regulatory staff requested those utilities that operate nuclear power plants, have applied for operating licenses, or have plants whose construction permit review was essentially complete, to assess the effects and consequences of a postulated rupture of piping containing high-energy fluids and located outside of the containment structure. These requests were issued by Mr. A. Giambusso, Deputy Director for Reactor Projects, Directorate of Licensing, in letters, most of which were dated in December 1972.

Because these plants were either in operation or in advanced stages of engineering design and construction, the request included guidance for corrective modifications that could be implemented by in-situ measures. Such modifications included relocation or rerouting of piping, installation of impingement barriers and encapsulation sleeves around high-stressed piping regions, provisions for venting of compartments subject to pressurization, addition of piping restraints, and strengthening of structural components of buildings.

From our review of responses submitted to the Regulatory staff, and from discussions with architect-engineering firms, we have learned that some of these organizations have inferred that the criteria contained in Mr. A. Giambusso's letter pertaining to corrective modifications for plants in advanced stages of construction and operation are applicable for the design of high-energy fluid systems outside the containment in new designs of nuclear power plants. It was not our intent that the criteria for corrective plant modifications be applied to new power plants that are in the initial design stages. We believe that a more direct approach, involving a rearrangement of the physical plant layout with a view to relocation of essential safety systems and components is appropriate for the new plants.

For the present, pending issuance of a planned AEC Regulatory Guide "Protection Against Postulated Events and Accidents Outside Containment," an acceptable implementation of Criterion 4 of the Commission's General Design Criteria listed in ~~Appendix A of~~ 10 CFR Part 50, Appendix A[52] as applied to new plants with respect to the design of structures, systems and components important to safety and located outside of containment is as follows:

I. <u>PIPING SYSTEMS CONTAINING HIGH-ENERGY FLUIDS[1] DURING NORMAL REACTOR OPERATION</u>

(a) The piping systems are isolated by adequate physical separation and remotely located from safety systems and components that are required to shut down the reactor safely and maintain the plant in a cold shutdown condition.

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[1] Refer to Appendix A for identification of high-energy fluid systems.

(b) Where isolation by remote location is impracticable, systems containing high-energy fluids, or portions of the systems, are enclosed within the structures suitably designed to protect adjoining safely systems and components required to shut down the reactor safely and maintain the plant in a cold shutdown condition from postulated pipe failures within the enclosure.

(c) Where both isolation by remote location (as specified in I.a) and enclosure in protective structures (as specified in I.b) are impracticable, systems containing high-energy fluids, or portions of the systems, are provided with restraints and protective measures such that the operability and integrity of structures, safety systems and components that are required to shut down condition are not impaired.

(d) Protective enclosures for the piping systems containing high-energy fluids are designed as Seismic Category I structures to withstand the combined effects of a postulated pipe break, the dynamic effects of pipe whipping, the jet impingement forces, and the compartment pressurization as a consequence of discharging fluids in combination with the specified seismic event of the Safe Shutdown Earthquake and normal operating loads.

(e) Piping systems containing high-energy fluids are designed so that the effects of a single postulated pipe break cannot, in turn, cause failures of other pipes or components with unacceptable consequences.

In addition, any systems, or portions of systems, that are designed to mitigate the consequences of a postulated pipe failure, and to place the reactor in the cold shutdown condition, are provided with design features that will ~~assure~~ensure the performance of their safety function, assuming a single active component failure.

(f) For a postulated pipe failure, the escape of steam, water, and heat from structures enclosing the high-energy fluid containing piping does not preclude: (1) the accessibility to surrounding areas important to the safe control of reactor operations, (2) the habitability of the control room, and (3) the ability of instrumentation, electric power supplies, and components and controls to initiate, actuate and complete a safety action. In this regard, a loss of redundancy is permissible but not the loss of function.

(g) The criteria for determination of postulated break locations are contained in the attached Appendix A, "Criteria for Determination of Postulated Pipe Break or Leakage Locations in Fluid Piping Systems Outside Containments."

II. PIPING SYSTEMS CONTAINING MODERATE-ENERGY FLUIDS[2] DURING REACTOR OPERATION

(a) Piping systems containing moderate-energy fluids are designed to comply with the criteria applied to high-energy fluid piping systems as listed under I above, except that

[2] Refer to Appendix A for identification of moderate-energy fluid systems.

the piping is postulated to develop a limited-size through-wall leakage crack instead of a pipe break.

(b) For each postulated leakage, design measures are included that provide protection from the effects of the resulting water spray and flooding to the same extent required to satisfy criterion I(e)(c). The criteria for determination of postulated leakage locations are contained in Appendix A.

The measures taken for the protection of structures, systems and components important to safety should not preclude the conduct of inservice examinations of ASME Class 2 and 3 pressure-retaining components as required by the rules of ASME Boiler and Pressure Vessel Code - Section XI, "Inservice Inspection of Nuclear Power Plant Components."

Although compliance with the design criteria listed above should be accomplished by plant arrangement and layouts utilizing the separation concept to the extent practicable, special consideration will be necessary to provide adequate protection where interconnection is unavoidable between high-energy fluid containing piping and piping of systems important to safety.

We are prepared to discuss with you these guidelines for the design of new nuclear power plants with regard to protection required against postulated breaks of high and moderate-energy piping outside of containment, particularly for those plants with construction permit applications currently under consideration.

Sincerely,

John F. O'Leary, Director
Directorate of Licensing

Enclosure: Appendix A

APPENDIX A TO J. F. O'LEARY LETTER OF JULY 12, 1972
CRITERIA FOR DETERMINATION OF POSTULATED BREAK AND LEAKAGE LOCATIONS
IN HIGH[a] AND MODERATE[b] ENERGY FLUID PIPING SYSTEMS
OUTSIDE OF CONTAINMENT STRUCTURES[c]

NOTE: Alphabetical superscripts designate footnotes at the end of Appendix A of J. F. O'Leary Letter dated July 12, 1972.[53]

A. High-Energy Fluid Systems

1. For piping systems that by plant arrangement and layout are isolated by remote location for structures, systems, and components important to safety,[d] pipe breaks[e] need not be postulated provided the requirements of A.4 are satisfied.

2. For piping systems that are enclosed in suitably designed concrete structures or compartments to protect structures, systems, and components important to safety, pipe break should be postulated at the following locations in each piping or branch run within the protective structure:

   a. the terminal ends[f] of the piping or branch run (except as exempted by the provisions of A.4), if located within the protective structure or compartment, and

   b. each fitting (i.e., elbow, tee, cross, non-standard fitting), and

   c. a minimum of one break selected in each piping or branch run within the protective structure or compartment at a location that results in the maximum loading from the impact of the postulated ruptured pipe and jet discharge force on wall, floor, and roof of the structure or compartment, including internal pressurization, and taking into account any piping restraints provided to limit pipe motions.

3. For portions of piping systems that can neither be isolated as specified in A.1, nor enclosed in protective structures as specified in A.2, pipe breaks should be postulated at the following locations in each piping or branch run within the confines of the structures or compartments that enclose or adjoin areas containing systems and components important to safety:

   a. the terminal ends[f] of piping or branch run (except as exempted by A.4), if located within the boundary of the confining structure or each compartment within the structure; and

   b. any intermediate location within the boundary of the confining structure or each compartment within the structure where the stresses[g] under the loadings associated with specified seismic events[h] and operational plant conditions[i] exceed 0.8 $(S_h + S_A)$[j] or, in lieu of these calculated stress-related locations, at each fitting (i.e., elbow, tree, cross, non-standard fitting); and

c. a minimum of two separated locations within the boundary of the confining structure of each compartment within the structure in piping or branch runs exceeding twenty pipe diameters in length; a minimum of one location in piping or branch runs twenty pipe-diameters or less in length except that no intermediate locations need to be postulated in branch runs that are three pipe-diameters or less in length. Intermediate break locations should be selected such that the maximum pipe whip and jet impingement will result, assuming for this purpose an unrestrained ruptured pipe.

4. For those portions of the piping passing through primary containment penetrations and extending to the first outside isolation valve, pipe breaks need not be postulated provided such piping is conservatively reinforced and restrained beyond the valve such that, in the event of a postulated pipe break outside containment, the transmitted pipe loads will neither impair the operability of the valve nor the integrity of the piping or the containment penetration. (A terminal end of such piping is considered to originate at this restraint location.)

B. Moderate-Energy Fluid Systems

1. For piping systems that by plant arrangement and layout are isolated and physically separated and remotely located from systems and components important to safety, through-wall leakage cracks need not be postulated.

2. For piping systems that are located in the same areas as high-energy fluid systems which, by the criteria of A.1 to A.3 have postulated pipe break locations, through-wall leakage cracks need not be postulated.

3. For piping systems that are located in areas containing systems and components important to safety, but where no high-energy fluid systems are present, through-wall leakage cracks should be postulated at the most adverse location to determine the protection needed to withstand the effects of the resulting water spray and flooding.

C. Side and Types of Pipe Breaks and Cracks

1. The following types of breaks should be postulated at the locations specified by the criteria listed under A. High-Energy Fluid Systems:

a. longitudinal breaks in piping runs and branch runs with nominal pipe sizes of 10 cm (4 inches)[54] and larger,

b. circumferential breaks in piping runs and branch runs exceeding a nominal pipe size of 2.5 cm (1 inch).[55]

2. The following leakage cracks are postulated at the locations specified by the criteria listed under B, Moderate-Energy Fluid Systems:

   a. through-wall leakage cracks in piping and branch runs exceeding a nominal pipe size of 2.5 cm (1 inch),[56] where the crack opening is assumed as 1/2 the pipe diameter in length and 1/2 the pipe wall thickness in width.

<u>FOOTNOTES</u>

~~1~~a. High-energy systems include those systems where either of the following conditions are met:

(a) the maximum operating temperature exceeds 95 °C (200 °F),[57] and

(b) the maximum operating pressure exceeds 1900 kPa (275 psig).[58]

~~2~~b. Moderate energy systems include those systems where both of the following conditions are met:

(a) the maximum operating temperature is 95 °C (200 °F)[59] or less, and

(b) the maximum operating pressure is 1900 kPa (275 psig)[60] or less.

c. These criteria are intended for the purpose of designing piping restraints and do not preclude consideration of other aspects of the NRC General Design Criteria, such as single failure criteria and other additional protective measures required to provide protection against environmental conditions incident to postulated accidents.[61]

~~3~~d. Structures, systems, and components important to safety, as specified herein refer to those plant features required to shut down the reactor safely and maintain the plant in the cold shutdown condition.

~~4~~e. Break in piping means (a) a complete circumferential pipe severance and, (b) a longitudinal split opening an area equal to the pipe area, but without pipe severance. Such breaks are assumed to occur at each specified break location, but not concurrently.

f. Terminal ends of pipe runs originate at points of maximum constraint (e.g., connections to vessels, pumps, valves, fittings that are rigidly anchored to structures) terminal ends of branch runs originate at pipe intersections and components that act as rigid constraints.[62]

~~5~~g. Either circumferential or longitudinal stresses derived on an elastically-calculated basis.

~~6~~h. Specified seismic events are earthquakes that produce at least 50 percent of the vibratory motion of the Safe Shutdown Earthquake (SSE).

7i. Operational plant conditions include normal reactor operation, upset conditions, (e.g., anticipated operational occurrences) and testing conditions.

8j. S_h is the allowable stress at maximum temperature, and S_A is the allowable stress range for expansion stresses for Class 2 and 3 piping as permitted by the rules of ASME Code Section III.

9 Terminal ends of pipe runs originate at points of maximum constraint (e.g., connections to vessels, pumps, valves, fittings that are rigidly anchored to structures) terminal ends of branch runs originate at pipe intersections and components that act as rigid constraints.[63]

10 These criteria are intended for the purpose of designing piping restraints and do not preclude consideration of other aspects of the AEC General Design Criteria, such as single failure criteria and other additional protective measures required to provide protection against environmental conditions incident to postulated accidents.[64]

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SRP Draft Section 3.6.1

Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Editorial	Changed "assure" to "ensure" to correct usage. (Global change for this SRP section.)
2.	Editorial	Corrected "Criteria" to "Criterion"
3.	Editorial	Introduced "GDC 4" as initialism for "General Design Criterion 4."
4.	Editorial	Defined SRP.
5.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW and put in numbered paragraph form to describe how SPLB reviews Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment and how other branches support review of this SRP section.
6.	Current review branch name and abbreviation	Changed review branch to Civil Engineering and Geosciences Branch (ECGB).
7.	Current review branch abbreviation	Changed to ECGB.
8.	Editorial, PI # 25792	Added a review interface with new SRP Section 3.12 with regard to ISLOCA issues.
9.	Integrated Impact 400	Added a Review Interface with proposed SRP Section 3.6.3 regarding review of leak-before-break applications. The EMCB was selected as the primary review branch based on PRB comments received on ROC # 88.
10.	Current review branch name and abbreviation	Changed review branch to ECGB.
11.	Editorial	Simplified for clarity and readability.
12.	Editorial	Changed to GDC because GDC was previously defined.
13.	SRP-UDP format item	Added Technical Rationale to ACCEPTANCE CRITERIA and put in numbered paragraph form to describe the bases for referencing the GDC.
14.	SRP-UDP format item	Added lead-in sentence for Technical Rationale.
15.	SRP-UDP format item	Added Technical Rationale for GDC 4.
16.	Editorial	Modified to eliminate use of gender-specific pronoun.
17.	Editorial	Modified to eliminate use of gender-specific pronoun.
18.	Current review branch abbreviation	Changed to ECGB.

Item	Source	Description
19.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
20.	Editorial	Modified to eliminate use of gender-specific pronoun.
21.	Editorial	Provided "SER" as abbreviation for "safety evaluation report."
22.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
23.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
24.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
25.	Editorial	Deleted reference to obsolete BTP designation.
26.	Current title of GDC 4	Changed to current title of GDC 4.
27.	Editorial	Changed "assure" to "ensure" to correct usage. (Global change for this Branch Technical Position.)
28.	Editorial	Deleted superscript since it appeared only once and was not identified.
29.	Editorial	Changed "to" to "from" to correct meaning of sentence.
30.	Integrated Impact No. 1404	Deleted reference to OBE.
31.	Integrated Impact Nos. 400 and 401	Referenced SRP Section 3.6.3 for leak-before-break evaluation.
32.	SRP-UDP format item	Deleted outdated scheduling information.
33.	Conversion to SI units	Added metric units for 200 °F.
34.	Conversion to SI units	Added metric units for 275 psig.
35.	Conversion to SI units	Added metric units for 200 °F.
36.	Conversion to SI units	Added metric units for 275 psig.
37.	SRP-UDP format item	Changed AEC to NRC.
38.	SRP-UDP format item	Changed AEC to NRC.
39.	Conversion to SI units	Added metric units for 200 °F.
40.	Conversion to SI units	Added metric units for 275 psig.

Item	Source	Description
41.	SRP-UDP format item	Added designation of footnotes at the end of Appendix B, Branch Technical Position SPLB 3-1.
42.	Conversion to SI units	Added metric units for 4 inches.
43.	Conversion to SI units	Added metric units for 1 inch.
44.	Integrated Impact No. 976	Replaced IEEE-279 with IEEE 603-1980 as the standard to satisfy the requirements of IEEE Std. 279.
45.	Integrated Impact No. 1407	The designation of IEEE-308 should be changed pending approval of a revised version by the NRC staff.
46.	Integrated Impact No. 1456	The designation of the ASME Code, Section III should be changed pending approval of a revised version by the NRC staff.
47.	Editorial	Corrected by changing SA to U.
48.	Integrated Impact No. 1456	The designation of the ASME Code, Section III should be changed pending approval of a revised version by the NRC staff.
49.	Integrated Impact No. 1456	The designation of the ASME Code, Section III should be changed pending approval of a revised version by the NRC staff.
50.	Integrated Impact No. 1456	The designation of the ASME Code, Section III should be changed pending approval of a revised version by the NRC staff.
51.	Integrated Impact No. 1409	The designation of USA Standard Code for Pressure Piping, ANSI B31.1.0-1967 should be changed pending approval of a revised version by the NRC staff.
52.	Editorial	Revised designation of 10 CFR Part 50, Appendix A.
53.	Editorial	Revised designation of superscripts for footnotes from numerical to alphabetical to avoid confusing with proposed changes in order of occurrence (Attachment A). (Global change for this Branch Technical Position.
54.	Conversion to SI units	Added metric units for 4 inches.
55.	Conversion to SI units	Added metric units for 1 inch.
56.	Conversion to SI units	Added metric units for 1 inch.
57.	Conversion to SI units	Added metric units for 200 °F.
58.	Conversion to SI units	Added metric units for 275 psig.
59.	Conversion to SI units	Added metric units for 200 °F.
60.	Conversion to SI units	Added metric units for 275 psig.

Item	Source	Description
61.	Editorial	Relocated footnote.
62.	Editorial	Relocated footnote.
63.	Editorial	Relocated footnote.
64.	Editorial	Relocated footnote.

SRP Draft Section 3.6.1
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
400	Include consideration of leak-before-break.	Branch Technical Position SPLB 3-1, paragraph B.3.e
401	Include consideration of leak-before-break.	Branch Technical Position SPLB 3-1, paragraph B.3.e
976	Revise citation of IEEE-279 in SRP Section 3.6.1 to cite IEEE 603-1980.	Branch Technical Position SPLB 3-1, Appendix B, paragraph 11(a)
1404	Delete reference to the OBE.	Branch Technical Position SPLB 3-1, paragraph B.2.b(1)
1407	Revise citation of IEEE-308 in SRP Section 3.6.1 pending staff review of latest version.	Branch Technical Position SPLB 3-1, Appendix B, paragraph 11(a)
1409	Revise citation of the USA Standard Code for Pressure Piping, ANSI/ASME B31.1.0-1967, Power Piping in SRP Section 3.6.1 pending staff review of latest version.	Branch Technical Position SPLB 3-1, Appendix B, footnote g
1456	Revise citation of ASME Boiler and Pressure Vessel Code, Section III in SRP Section 3.6.1 pending staff review of latest version.	Branch Technical Position SPLB 3-1, Appendix B, footnote e Branch Technical Position SPLB 3-1, Appendix B, footnote f Branch Technical Position SPLB 3-1, Appendix B, footnote g