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PRELIMINARY REVIEW EVALUATION DRAFT Q1 QUESTIONS OF PSAR FOR WASHINGTON PUBLIC POWER SUPPLY SYSTEM, DOCKET NOS. 50-508 & 509

Plant Name: Washington Nuclear Project No. 3 (WNP-3) and No. 5 (WNP-5)
Docket Nos: 50-508 & 509
Licensing Stage: PSAR
Responsible Branch and Project Manager: LWR 1-1, P. O'Reilly
Responsible TR Branch and Technical Reviewer: MEB, F. Cherny, P. Chen
Requested Completion Date: 9/13/74
Description of Response: Draft Q-1 Review of PSAR
Review Status: Complete

1. Area of Review

The Mechanical Engineering Branch area of review concerns the design criteria of Sections 3.6, 3.9, 3.10, 4.2, 5.2 and 5.5 of the Standard Format (Regulatory Guide 1.70) dated October 1972. Since the WNP - 3 and 5 PSAR references CESSAR, only non-CESSAR portions of these sections have been reviewed.

2. Positions and areas in which additional information is required are identified in the enclosure.

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11.0 MECHANICAL ENGINEERING

110.1 (3.6.2.1) Under 3.6.2.1.4(a) piping systems having an internal pressure of up to 275 psia and fluid temperatures not in excess of 200°F are excluded from pipe break criteria. This is not consistent with Regulatory Guide 1.46 nor the present MEB position. The present MEB position is that through wall leakage cracks should be postulated for such piping as delineated in Attachment A which is generally applicable for piping outside the containment.

110.2 (3.6.2.2) PSAR states that criteria for postulating pipe breaks for piping outside the containment will be per AEC letter from J. O'Leary of 7/12/73. This is acceptable, however, implementation of this criteria should be as contained in Attachment A.

110.3 (3.6.3.1)

(1) Provide loading combinations and stress criteria for normal, upset, and emergency conditions for Class 1, 2 and 3 piping in the A/E - BOP scope.

(2) Provide more specific criteria than "per code" for faulted condition stress criteria for Class 1 piping. For example, ASME Section III permits the use of Appendix F of the code for faulted conditions; but, does not require it. State specifically what is to be used.

(3) Provide specific design details for the three types of piping penetration guard pipes. Also discuss the access provisions to carry out inservice inspection of the flued head to process pipe welds for the Type I and III penetrations.

110.4 (3.6.4.1)

(1) Identify the computer program to be used for the calculation of postulated pipe break and if the program is not widely used in the nuclear industry, provide justification for its applicability and validity for this type of analysis.

(2) In the computation of the thrust force using the simplified forcing function, justify the use of P_{sat} in lieu of P_o for compressed (flashing) or saturated water.

110.5 (3.6.4.2)

(1) For unchoked flow, the Regulatory staff will accept use of a model with a uniform half angle of dispersion not exceeding 10°.

(2) In calculating jet impingement force as described in Eq. (1), the definition of the velocity ratio $\overline{U}m$ is not clear. Current MEB position requires that the steady state forcing function for jet impingement should have a magnitude (T) not less than

110.5
(3.6.4.2)

T = KPA

Where P = system pressure prior to pipe break
A = pipe break area, and
K = thrust coefficient.

(3) For choked flow, provide justification for the following assumed angles of dispersion for the jets:

Flashing water	- 45°
Steam	- 22°
Non- Flashing Water	- 25°

and clarify the pressure that is going to be used for calculating jet force.

(4) Define the symbols for calculating the jet impingement forces as given in cases A, B, C and D. In those formulas, explain the missing pressure force component.

(5) For the calculation of the Drag Force (Case C) expand the discussion to include a broader range of Reynolds numbers other than the range of $R_e = 10^3$ to 10^5 given.

110.6
(3.9.1.1)

(1) The information presented in this section of the PSAR does not satisfy the requirements concerning "Seismic Category I Mechanical Equipment Testing and Analysis - C.E. Scope of Supply" for plants currently undergoing review. Provide the appropriate commitments from CESSAR.

(2) Clarify type of operating experience to be used to verify that equipment will operate under SSE conditions.

(3) Provide commitment that all Category I mechanical equipment and supports will be qualified to requirements of specifications 7-74 in Appendix 3.9.A.

(4) In paragraph 3.02 d of Appendix 3.9.A, when using the Response Spectrum Modal Analysis method, provide criteria for determining closely space modes.

(5) In Appendix 3.9.A, paragraph 3.02.e permits an allowable stress of 0.9 of the material yield stress for faulted conditions. This is not consistent with limits stated per Table 3.9.3 of the PSAR. Revise the Appendix to conform with Table 3.9.3.

110.7 (3.9.1.2) (3.10) The seismic qualification program described in this section is not totally acceptable. Revise the program to be in accordance with criteria provided in Attachment B "Electrical and Seismic Qualification Program."

110.8 (3.9.2.4)

(1) In the last sentence of Part I of Appendix 3.9.B change "will" to "may".

(2) In Section II of Appendix 3.9.B expand the valve operability testing criteria to include the valve design pressure.

(3) In Section II of Appendix 3.9.B under criterion d state the Qualification Standards to be employed.

(4) In Appendix 3.9.B define the horizontal and vertical accelerations to be used for static valve qualification.

(5) In Appendix 3.9.B, Section II, your position that for valves with natural frequencies less than 33 Hz operability can be verified without performing valve exercising per step C requires justification.

110.9 (3.9.2.5) Provide more specific equations of motion and discuss methods of solution for the dynamic analysis for open and closed systems.

110.10 (3.9.2.7) (5.2.19) The information provided in this section is not adequate. In addition to the nominal pipe size which determine whether ASME Class 2 and 3 piping will be field run, identify in the PSAR those Category I piping systems which will be field run. Include any special or simplified procedures which will be used for designing and installing this piping.

110.11 (3.10.2) Provide the specific criteria that will be used to guarantee operability of instrumentation and electrical equipment, not furnished by C.E., under faulted conditions when a dynamic analysis without performance testing is employed in the design of this equipment.

Attachment A

BRANCH TECHNICAL POSITION-MEB NO. 1
MECHANICAL ENGINEERING BRANCH
DIRECTORATE OF LICENSING
CRITERIA FOR
POSTULATED FAILURE AND LEAKAGE LOCATIONS IN
FLUID SYSTEM PIPING OUTSIDE CONTAINMENT

The following criteria are within the review responsibility of the Mechanical Engineering Branch with the exception of I.A., II.A., II.D., II.E and 1.a., 1.b., 1.c., 2.a and 2.c.(3) of Appendix A.

I. *High-Energy Fluid System*[1/] Piping

A. *Fluid Systems* Separated from *Essential Structures, Systems & Components*

For the purpose of satisfying the separation provisions of 1.a. of Appendix A, a review of the piping layout and plant arrangement drawings should clearly show that the effects of postulated piping breaks at any location are isolated or physically remote from *essential structures, systems, and components*. At the designer's option, break locations as determined from I.C., I.D., and I.E below may be selected for this purpose.

B. *Fluid System* Piping Between Containment Isolation Valves

Breaks need not be postulated in those portions of piping identified in 2.C.(1) and 2.C.(2) of Appendix A provided they meet the requirements of ASME Code, Section III - Subarticle NE-1110 and are designed to meet the following additional requirements:

1/ See Glossary for definitions of italicized phrases.

1. The following design stress and fatigue limits should not be exceeded;

<u>For ASME Code, Section III, Class 1 Piping</u>

(a) Maximum stress ranges should not exceed the following limits:

Ferritic steel $\leq 2.0S_m$

Austenitic steel $\leq 2.4S_m$.

(b) The maximum stress range between any two load sets (including the zero load set) should be calculated by Eq. (10) in Par. NB-3653, ASME Code, Section III, for *upset plant conditions* and an OBE event transient.

If the calculated maximum stress range of Eq. (10) exceeds the limits of I.B.1(a) but is not greater than $3S_m$, the limit of I.B.1(c) should be met.

If the calculated maximum stress range of Eq. (10) exceeds $3S_m$, the stress ranges calculated by both Eq. (12) and Eq. (13) should meet the limits of I.B.1(a) and the limit of I.B.1(c).

(c) Cumulative usage factor ≤ 0.1, as required by I.B.1(b).

<u>For ASME Code, Section III, Class 2 Piping</u>

Maximum stress range as calculated by Eq. (9) and (10) in Par. NC-3652, ASME Code, Section III, considering *upset plant conditions* (i.e., sustained loads, occasional loads, and thermal expansion) and an OBE event should not exceed $(S_c + S_h)$[2/].

2. Welded attachments, for pipe supports or other purposes, to these portions of piping should be avoided except where detailed stress analyses, or tests, are performed to demonstrate compliance with the limits of I.B.1.

3. The number of piping circumferential and longitudinal welds and branch connections should be minimized.

4. The length of the piping run should be reduced to the minimum length practical.

5. The design at points of pipe fixity (e.g., pipe anchors or welded connections at containment penetrations) should not require welding directly to the outer surface of the piping (e.g., fluid integral forged pipe fittings may be used) except where detailed stress analyses are performed to demonstrate compliance with the limits of I.B.1.

6. Geometric discontinuities, such as at pipe-to-valve section transitions, at branch connections, and at changes in pipe wall thickness should be designed to minimize the discontinuity stresses.

C. *Fluid Systems* Enclosed Within Protective Structures

1. Breaks in ASME Code, Section III, Class 2 and 3 piping should

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[2/] The limit of $0.8(1.2\ S_h + S_A)$ may be used in lieu of $(S_c + S_h)$.

be postulated at the following locations in each piping and branch run (except those portions of *fluid system* piping identified in I.3.) within a protective structure containing *essential systems and components* and designed to satisfy the provisions of 1.b. or 1.c. of Appendix A:

a. At *terminal ends* of the pressurized portions of the run if located within the protective structure.

b. At intermediate locations selected by either of the following criteria:

(i) At each pipe fitting (e.g., elbow, tee, cross, and non-standard fitting) or, if the run contains no fittings, at one location at each extreme of the run (a *terminal end*, if located within the protective structure may substitute for one intermediate break).

(ii) At each location where the stresses[3/] exceed $(S_h + S_c)$[2/] but at not less than two separated locations chosen on the basis of highest stress[4/]. In the case of a straight pipe run without any pipe fittings or welded attachments and stresses below $(S_h + S_c)$, a minimum of one location chosen on the basis of highest stress.

[3/] Stresses associated with *normal* and *upset plant conditions*, and an OBE event as calculated by Eq. (9) and (10), Par. NC-3652 of the ASME Code, Section III, for Class 2 and 3 piping

[4/] Two highest stress points; select second point at least 10% below the highest stress.

2. Breaks in non-nuclear class piping should be postulated at the following locations in each piping or branch run:

a. At *terminal ends* of the pressurized portions of the run if located within the protective structure.

b. At each intermediate pipe fitting and welded attachment.

D. *Fluid Systems* Not Enclosed Within Protective Structures

1. Breaks in ASME Code, Section III, Class 2 and 3 piping, should be postulated at the following locations in each piping and branch run (except those portions of *fluid system* piping identified in I.B) outside but routed alongside, above, or below a protective structure containing *essential systems and components* and designed to satisfy the provisions of 1.b, or 1.c of Appendix A.

a. At *terminal ends* of pressurized portions of the run if located adjacent to the protective structure.

b. At intermediate locations selected by either of the following criteria:

(i) At each pipe fitting (e.g., elbow, tee, cross, and non-standard fitting).

(ii) At each location where the stresses[3/] exceed $(S_h + S_c)$[2/] but at not less than two separated locations chosen on the basis of highest stress[4/]. In the case of a straight pipe run without any pipe fittings or welded attachments and stresses below $(S_h + S_c)$, a minimum of one location chosen on the basis of highest stress.

2. Breaks in non-nuclear class piping should be postulated at the following locations in each piping or branch run:

   a. At terminal ends of pressurized portions of the run if located adjacent to the protective structure.

   b. At each intermediate pipe fitting and welded attachment.

II. *Moderate-Energy Fluid System* Piping

A. *Fluid Systems* Separated from *Essential Structures, Systems & Components*

For the purpose of satisfying the separation provisions of 1.a. of Appendix A, a review of the piping layout and plant arrangement drawings should clearly show that the effects of through-wall leakage cracks at any location are isolated or physically remote from *essential structures, systems, and components*.

B. *Fluid System* Piping Between Containment Isolation Valves

Breaks need not be postulated in those portions of piping identified in 2.c. of Appendix A provided they meet the requirements of ASME Code, Section III - Subarticle NE-1110, and are designed such that the stresses do not exceed $0.5(S_h + S_c)$ [5/] for ASME Code, Section III, Class 2 piping.

5/ The limit 0.4(1.2 S ...

C. *Fluid Systems* Within or Outside and Adjacent to Protective Structures

Through-wall leakage cracks should be postulated in *fluid system* piping located within or outside and adjacent to protective structures containing *essential systems and components* and designed to satisfy the provisions of 1.b. or 1.c. of Appendix A, except where exempted by II.B, II.D, or in those portions of ASME Code, Section III, Class 2 or 3 piping or non-nuclear piping where the stresses are less than $0.5(S_h + S_c)$[5/]. The cracks should be postulated to occur individually at locations that result in the maximum effects from fluid spraying and flooding, and the consequent hazards or environmental conditions developed.

D. *Moderate-Energy Fluid Systems* in Proximity to *High-Energy Fluid Systems*

Cracks need not be postulated in *moderate-energy fluid system* piping located in an area in which a break in *high-energy fluid system* piping is postulated, provided such cracks would not result in more limiting environmental conditions than the high-energy piping break. Where a postulated leakage crack in the *moderate-energy fluid system* piping results in more limiting environmental conditions than the break in proximate *high-energy fluid system* piping, the provisions of II.C should be applied.

E. *Fluid Systems* Qualifying as *High-Energy* or *Moderate-Energy Systems*

Through-wall leakage cracks instead of breaks may be postulated in the piping of those *fluid systems* that qualify as *high energy fluid systems* for only short operational periods[6/] but qualify as *moderate-energy fluid systems* for the major operational period.

III. Type of Breaks and Leakage Cracks in *Fluid System* Piping

A. Circumferential Pipe Breaks

The following circumferential breaks should be postulated in *high-energy fluid system* piping at the locations specified in Section I above:

1. Circumferential breaks should be postulated in *fluid system* piping and branch runs exceeding a nominal pipe size of 1 inch, except that, if the maximum stress range in the circumferential direction is at least twice that in the axial direction, only a longitudinal break need be postulated. Instrument lines, one inch and less nominal pipe size for tubing should meet the provisions of Regulatory Guide 1.11.

2. Where break locations are selected at pipe fittings without the benefit of stress calculations, breaks should be postulated at each pipe-to-fitting weld. If detailed stress analyses

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6/ An operational period is considered "short" if the fraction of time that the system operates within the pressure-temperature conditions specified for *high-energy fluid systems* is less than 2 percent of the time that the system operates as a *moderate energy fluid system* (e.g., systems such as the reactor decay heat removal systems qualify as *moderate-energy fluid systems;* however, systems such as auxiliary feedwater systems operated during PWR reactor startup, hot standby, or shutdown qualify as *high-energy fluid systems*).

(e.g., finite element analyses) or tests are performed, the maximum stressed location in the fitting may be selected instead of the pipe-to-fitting weld.

3. Circumferential breaks should be assumed to result in pipe severance and separation amounting to a one-diameter lateral displacement of the ruptured piping sections unless physically limited by piping restraints, structural members, or piping stiffness as may be demonstrated by inelastic limit analysis (e.g., a plastic hinge in the piping is not developed under loading).

4. The dynamic force of the jet discharge at the break location should be based on the effective cross-sectional flow area of the pipe and on a calculated fluid pressure as modified by an analytically or experimentally determined thrust coefficient. Limited pipe displacement at the break location, line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge.

5. Pipe whipping should be assumed to occur in the plane defined by the piping geometry and configuration, and to cause pipe movement in the direction of the jet reaction.

B. Longitudinal Pipe Breaks

The following longitudinal breaks should be postulated in *high-energy fluid system* piping at the locations of each circumferential break specified in III.A.:

1. Longitudinal break in *fluid system* piping and branch runs should be postulated in nominal pipe sizes 4-inch and larger, except that, if the maximum stress range in the axial direction is at least twice that in the circumferential direction, only a circumferential break need be postulated.

2. Longitudinal breaks need not be postulated at *terminal ends* if the piping at the *terminal ends* contains no longitudinal pipe welds and major geometric discontinuities at the circumferential weld joints of the *terminal ends* are designed to minimize discontinuity stresses.

3. Longitudinal breaks should be assumed to result in an axial split without pipe severance. Splits should be located (but not concurrently) at two diametrically-opposed points on the piping circumference such that a jet reaction causing out-of-plane bending of the piping configuration results.

4. The dynamic force of the fluid jet discharge should be based on a circular or elliptical (2D x 1/2D) break area equal to the effective cross-sectional flow area of the pipe at the break location and on a calculated fluid pressure modified by an analytically or experimentally determined thrust coefficient as determined for a circumferential break at the same location. Line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge.

5. Piping movement should be assumed to occur in the direction of the jet reaction unless limited by structural members, piping restraints, or piping stiffness as demonstrated by inelastic limit analysis.

C. Through-Wall Leakage Cracks

The following through-wall leakage cracks should be postulated in *moderate-energy fluid system* piping at the locations specified in Section II above:

1. Cracks should be postulated in *moderate-energy fluid system* piping and branch runs exceeding a nominal pipe size of 1 inch.

2. Fluid flow from a crack should be based on a circular opening of area equal to that of a rectangle one-half pipe-diameter in length and one-half pipe wall thickness in width.

3. The flow from the crack should be assumed to result in an environment that wets all unprotected components within the compartment, with consequent flooding in the compartment and communicating compartments. Flooding effects may be determined on the basis of a conservatively-estimated time period required to effect corrective actions.

APPENDIX A

PLANT ARRANGEMENT CRITERIA AND SELECTED PIPING DESIGN FEATURES

1. Plant Arrangement

Protection of *essential structures, systems, and components* 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 one of the following plant arrangement considerations:

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

b. *Fluid system* piping or portions thereof not satisfying the provisions of 1.a. above should be enclosed within structures or compartments designed to protect nearby *essential structures, 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 1.a. or 1.b. above should be limited to those for which the above provisions are impractical. 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 such cases, redundant design features, separated or otherwise protected from effects of *postulated piping failures*, or additional protection should be provided so that reactor shutdown is assured in the event of a failure in the interconnecting piping of (1), or in the dual function piping of (2). 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*.

2. <u>Design Features</u>

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 1.b. or 1.c. above should be designed to Seismic Category I requirements. The effects of a *postulated piping failure* (i.e., pipe whip, jet impingement, pressurization of compartment, water spray, and flooding, as appropriate) in combination with loadings associated with the Safe Shutdown Earthquake and normal operation should be used for the design of required protective 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 the effects of a postulated break[1/] in one pipe cannot, in turn, rupture other nearby pipes or components which could result in unacceptable offsite consequences or in loss of capability of *essential systems and components* to initiate, actuate, and complete actions required for reactor shutdown.

c. *Fluid system* piping between containment isolation valves should meet the following design provisions:

[1/] In the design of piping restraint, an unrestrained whipping pipe should be considered capable of (a) rupturing impacted pipes of smaller nominal pipe sizes and (b) developing a through-wall leakage crack in larger nominal pipe sizes with thinner wall thicknesses except where experimental or analytical data for specific impact energies demonstrate the capability to withstand the impact without failure.

(1) Portions of *fluid system* piping between isolation valves of single barrier containment structures (including any rigid connection to the containment penetration) that connect, on a continuous or intermittent basis to the reactor coolant pressure boundary or the steam and feedwater systems of PWR plants should be designed to the stress limits specified in I.B. or II.B. of this document.

These portions of *high-energy fluid system* piping should be provided with pipe whip restraints (i.e., capable of resisting bending and torsional moments) located reasonably close to the containment isolation valves. The restraints should be designed to withstand the loadings resulting from a *postulated piping failure* beyond these portions of piping so that neither isolation valve operability nor the leaktight integrity of the containment will be impaired.

Terminal ends of the piping runs outside containment should be considered to originate at the pipe whip restraint locations outside containment.

Where containment isolation valves are not required inside containment, those portions of the fluid system piping extending from the outside isolation valve to either the rigid pipe connection to the containment penetration or the first pipe whip restraint inside containment should be considered as the boundary of the system piping required to meet the above design limits and restraint provisions.

(2) Portions of *fluid system* piping between isolation valves of dual barrier containment structures should not exceed the stress limits in I.B or II.B. of this document. These portions of high-energy fluid system piping that pass through the annulus, and whose failure could affect the leaktight integrity of the containment structure or result in pressurization of the annulus beyond design limits, should be provided with pipe whip restraints (i.e., capable of resisting bending and torsional moments) located reasonably close to the containment isolation valves and should be provided with an enclosing structure or guard pipe. Restraints should be designed to withstand the loadings resulting from a *postulated piping failure* beyond these portions of piping so that neither isolation valve operability nor the leaktight integrity of the associated containment penetration will be impaired.

Terminal ends of the piping runs outside containment should be considered to originate at the pipe whip restraint locations outside containment.

For the purpose of establishing the design parameters (e.g., pressure, temperature, axial loads) only of the enclosing structure or guard pipe, a full flow area break should be assumed in that portion of piping within the enclosing structure or guard pipe.

(3) For those portions of *fluid system* piping identified in 2.c.(1) and 2.c.(2) above, the extent of inservice examination conducted as specified in Division 1 of Section XI of the ASME Code during each inspection interval should be increased to provide volumetric examination of 100 percent of the circumferential and longitudinal weld joints in piping identified in Section III.A.1. and Section III.B.1. of this document. The areas subject to examination should comply with the requirements of the following categories as specified in Section XI of the ASME Code:

(a) ASME Class 1 piping welds, Examination Category B-J in Table IWB-2500.

(b) ASME Class 2 piping welds, Examination Category C-F and C-G in Table IWC-2500.

GLOSSARY

Essential Structures, Systems, and Components. Structures, systems, and components required for reactor shutdown without off-site power or to mitigate the consequences of a *postulated piping failure* in *fluid system* piping that results in trip of the turbine-generator or the reactor protection system.

Fluid Systems. *High and moderate energy fluid systems* that are subject to the postulation of piping failures against which protection of *essential structures, 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 200°F, or

b. maximum operating pressure exceeds 275 psig.

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 200°F or less, and

b. maximum operating pressure is 275 psig 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 this document.

S_h, S_c, *and* S_A. Allowable stresses at maximum (hot) temperature, at minimum (cold) temperature, and allowable stress range for thermal expansion respectively, as defined in Article NC-3600 of the ASME Code, Section III.

S_m. Design stress intensity as defined in Article NB-3600 of the ASME Code, Section III.

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.

Terminal Ends. Extremeties of piping runs that connect to structures, components (e.g., vessels, pumps, valves), or pipe anchors that act as rigid constraints to piping thermal expansion. A branch connection to a main piping run is a terminal end of the branch run.

Attachment B

ELECTRICAL AND MECHANICAL EQUIPMENT SEISMIC QUALIFICATION PROGRAM

I. Seismic Test for Equipment Operability

1. A test program is required to confirm the functional operability of all Seismic Category I electrical and mechanical equipment and instrumentation during and after an earthquake of magnitude up to and including the SSE. Analysis without testing may be acceptable only if structural integrity alone can assure the design intended function. When a complete seismic testing is impracticable, a combination of test and analysis may be acceptable.

2. The characteristics of the required input motion should be specified by one of the following:

   (a) response spectrum
   (b) power spectral density function
   (c) time history

   Such characteristics, as derived from the structures or systems seismic analysis, should be representative of the input motion at the equipment mounting locations.

3. Equipment should be tested in the operational condition. Operability should be verified during and after the testing.

4. The actual input motion should be characterized in the same manner as the required input motion, and the conservatism in amplitude and frequency content should be demonstrated.

5. Seismic excitation generally have a broad frequency content. Random vibration input motion should be used. However, single frequency input, such as sine beats, may be applicable provided one of the following conditions are met:

   (a) The characteristics of the required input motion indicate that the motion is dominated by one frequency (i.e., by structural filtering effects).

   (b) The anticipated response of the equipment is adequately represented by one mode.

   (c) The input has sufficient intensity and duration to excite all modes to the required magnitude, such that the testing response spectra will envelope the corresponding response spectra of the individual modes.

6. The input motion should be applied to one vertical and one principal (or two orthogonal) horizontal axes simultaneously unless it can be demonstrated that the equipment response along the vertical direction is not sensitive to the vibratory motion along the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear resultant input is avoided. The acceptable alternative is to have vertical and horizontal inputs in-phase, and then repeated with inputs 180 degrees out-of-phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.

7. The fixture design should meet the following requirements:

   (a) Simulate the actual service mounting
   (b) Cause no dynamic coupling to the test item.

8. The in-situ application of vibratory devices to superimpose the seismic vibratory loadings on the complex active device for operability testing is acceptable when application is justifiable.

9. The test program may be based upon selectively testing a representative number of mechanical components according to type, load level, size, etc. on a prototype basis.

II. <u>Seismic Design Adequacy of Supports</u>

1. Analyses or tests should be performed for all supports of electrical and mechanical equipment and instrumentation to ensure their structural capability to withstand seismic excitation.

2. The analytical results must include the following:

   (a) The required input motions to the mounted equipment should be obtained and characterized in the manner as stated in Section I.2.

   (b) The combined stresses of the support structures should be within the limits of ASME Section III, Subsection NF - "Component Support Structures" (draft version) or other comparable stress limits.

3. Supports should be tested with equipment installed. If the equipment is inoperative during the support test, the response at the equipment mounting locations should be monitored and characterized in the manner as stated in Section I.2. In such a case, equipment should be tested separately and the actual input to the equipment should be more conservative in amplitude and frequency content than the monitored response.

4. The requirements of Sections I.2, I.4, I.5, I.6 and I.7 are applicable when tests are conducted on the equipment supports.

SEP 1 3 1974

R. C. DeYoung, Assistant Director
for Light Water Reactors, Group 1
Directorate of Licensing

PRELIMINARY REVIEW EVALUATION DRAFT Q1 QUESTIONS OF PSAR FOR WASHINGTON PUBLIC POWER SUPPLY SYSTEM, DOCKET NOS. 50-508 & 509

Plant Name: Washington Nuclear Project No. 3 (WNP-3) and No. 5 (WNP-5)
Docket Nos: 50-508 & 509
Licensing Stage: PSAR
Responsible Branch and Project Manager: LWR 1-1, P. O'Reilly
Responsible TR Branch and Technical Reviewer: MEB, F. Cherny, P. Chen
Requested Completion Date: 9/13/74
Description of Response: Draft Q-1 Review of PSAR
Review Status: Complete

1. **Area of Review**

   The Mechanical Engineering Branch area of review concerns the design criteria of Sections 3.6, 3.9, 3.10, 4.2, 5.2 and 5.5 of the Standard Format (Regulatory Guide 1.70) dated October 1972. Since the WNP - 3 and 5 PSAR references CESSAR, only non-CESSAR portions of these sections have been reviewed.

2. Positions and areas in which additional information is required are identified in the enclosure.

Original signed by
R. R. Maccary

R. R. Maccary, Assistant Director
for Engineering
Directorate of Licensing

cc w/encl:
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Docket Files 50-508 & 509
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DATE	9/13/74	9/13/74	9/13/74	9/13/74

Form AEC-318 (Rev. 9-53) AECM 0240 GPO C43 16 81465-1 320-284

11.0 MECHANICAL ENGINEERING

110.1 (3.6.2.1) Under 3.6.2.1.4(a) piping systems having an internal pressure of up to 275 psia and fluid temperatures not in excess of 200°F are excluded from pipe break criteria. This is not consistent with Regulatory Guide 1.46 nor the present MEB position. The present MEB position is that through wall leakage cracks should be postulated for such piping as delineated in Attachment A which is generally applicable for piping outside the containment.

110.2 (3.6.2.2) PSAR states that criteria for postulating pipe breaks for piping outside the containment will be per AEC letter from J. O'Leary of 7/12/73. This is acceptable, however, implementation of this criteria should be as contained in Attachment A.

110.3 (3.6.3.1)

(1) Provide loading combinations and stress criteria for normal, upset, and emergency conditions for Class 1, 2 and 3 piping in the A/E - BOP scope.

(2) Provide more specific criteria than "per code" for faulted condition stress criteria for Class 1 piping. For example, ASME Section III permits the use of Appendix F of the code for faulted conditions; but, does not require it. State specifically what is to be used.

(3) Provide specific design details for the three types of piping penetration guard pipes. Also discuss the access provisions to carry out inservice inspection of the flued head to process pipe welds for the Type I and III penetrations.

110.4 (3.6.4.1)

(1) Identify the computer program to be used for the calculation of postulated pipe break and if the program is not widely used in the nuclear industry, provide justification for its applicability and validity for this type of analysis.

(2) In the computation of the thrust force using the simplified forcing function, justify the use of P_{sat} in lieu of P_o for compressed (flashing) or saturated water.

110.5 (3.6.4.2)

(1) For unchoked flow, the Regulatory staff will accept use of a model with a uniform half angle of dispersion not exceeding 10°.

(2) In calculating jet impingement force as described in Eq. (1), the definition of the velocity ratio $\bar{U}m$ is not clear. Current MEB position requires that the steady state forcing function for jet impingement should have a magnitude (T) not less than

110.5 (3.6.4.2)

$$T = KPA$$

Where P = system pressure prior to pipe break
A = pipe break area, and
K = thrust coefficient.

(3) For choked flow, provide justification for the following assumed angles of dispersion for the jets:

Flashing water - 45°
Steam - 22°
Non- Flashing Water - 25°

and clarify the pressure that is going to be used for calculating jet force.

(4) Define the symbols for calculating the jet impingement forces as given in cases A, B, C and D. In those formulas, explain the missing pressure force component.

(5) For the calculation of the Drag Force (Case C) expand the discussion to include a broader range of Reynolds numbers other than the range of $R_e = 10^3$ to 10^5 given.

110.6 (3.9.1.1)

(1) The information presented in this section of the PSAR does not satisfy the requirements concerning "Seismic Category I Mechanical Equipment Testing and Analysis - C.E. Scope of Supply" for plants currently undergoing review. Provide the appropriate commitments from CESSAR.

(2) Clarify type of operating experience to be used to verify that equipment will operate under SSE conditions.

(3) Provide commitment that all Category I mechanical equipment and supports will be qualified to requirements of specifications 7-74 in Appendix 3.9.A.

(4) In paragraph 3.02 d of Appendix 3.9.A, when using the Response Spectrum Modal Analysis method, provide criteria for determining closely space modes.

(5) In Appendix 3.9.A, paragraph 3.02.e permits an allowable stress of 0.9 of the material yield stress for faulted conditions. This is not consistent with limits stated per Table 3.9.3 of the PSAR. Revise the Appendix to conform with Table 3.9.3.

110.7 (3.9.1.2) (3.10) The seismic qualification program described in this section is not totally acceptable. Revise the program to be in accordance with criteria provided in Attachment B "Electrical and Seismic Qualification Program."

110.8 (3.9.2.4)

(1) In the last sentence of Part I of Appendix 3.9.B change "will" to "may".

(2) In Section II of Appendix 3.9.B expand the valve operability testing criteria to include the valve design pressure.

(3) In Section II of Appendix 3.9.B under criterion d state the Qualification Standards to be employed.

(4) In Appendix 3.9.B define the horizontal and vertical accelerations to be used for static valve qualification.

(5) In Appendix 3.9.B, Section II, your position that for valves with natural frequencies less than 33 Hz operability can be verified without performing valve exercising per step C requires justification.

110.9 (3.9.2.5) Provide more specific equations of motion and discuss methods of solution for the dynamic analysis for open and closed systems.

110.10 (3.9.2.7) (5.2.19) The information provided in this section is not adequate. In addition to the nominal pipe size which determine whether ASME Class 2 and 3 piping will be field run, identify in the PSAR those Category I piping systems which will be field run. Include any special or simplified procedures which will be used for designing and installing this piping.

110.11 (3.10.2) Provide the specific criteria that will be used to guarantee operability of instrumentation and electrical equipment, not furnished by C.E., under faulted conditions when a dynamic analysis without performance testing is employed in the design of this equipment.

Attachment A

BRANCH TECHNICAL POSITION-MEB NO. 1
MECHANICAL ENGINEERING BRANCH
DIRECTORATE OF LICENSING
CRITERIA FOR
POSTULATED FAILURE AND LEAKAGE LOCATIONS IN
FLUID SYSTEM PIPING OUTSIDE CONTAINMENT

The following criteria are within the review responsibility of the Mechanical Engineering Branch with the exception of I.A., II.A., II.D., II.E and 1.a., 1.b., 1.c., 2.a and 2.c.(3) of Appendix A.

I. *High-Energy Fluid System*[1/] Piping

A. *Fluid Systems* Separated from *Essential Structures, Systems & Components*

For the purpose of satisfying the separation provisions of 1.a. of Appendix A, a review of the piping layout and plant arrangement drawings should clearly show that the effects of postulated piping breaks at any location are isolated or physically remote from *essential structures, systems, and components*. At the designer's option, break locations as determined from I.C., I.D., and I.E below may be selected for this purpose.

B. *Fluid System* Piping Between Containment Isolation Valves

Breaks need not be postulated in those portions of piping identified in 2.C.(1) and 2.C.(2) of Appendix A provided they meet the requirements of ASME Code, Section III - Subarticle NE-1110 and are designed to meet the following additional requirements:

1/ See Glossary for definitions of italicized phrases.

1. The following design stress and fatigue limits should not be exceeded;

For ASME Code, Section III, Class 1 Piping

(a) Maximum stress ranges should not exceed the following limits:

Ferritic steel $\leq 2.0S_m$

Austenitic steel $\leq 2.4S_m$.

(b) The maximum stress range between any two load sets (including the zero load set) should be calculated by Eq. (10) in Par. NB-3653, ASME Code, Section III, for *upset plant conditions* and an OBE event transient.

If the calculated maximum stress range of Eq. (10) exceeds the limits of I.B.1(a) but is not greater than $3S_m$, the limit of I.B.1(c) should be met.

If the calculated maximum stress range of Eq. (10) exceeds $3S_m$, the stress ranges calculated by both Eq. (12) and Eq. (13) should meet the limits of I.B.1(a) and the limit of I.B.1(c).

(c) Cumulative usage factor ≤ 0.1, as required by I.B.1(b).

For ASME Code, Section III, Class 2 Piping

Maximum stress range as calculated by Eq. (9) and (10) in Par. NC-3652, ASME Code, Section III, considering *upset plant conditions* (i.e., sustained loads, occasional loads, and thermal expansion) and an OBE event should not exceed $(S_c + S_h)$[2/].

2. Welded attachments, for pipe supports or other purposes, to these portions of piping should be avoided except where detailed stress analyses, or tests, are performed to demonstrate compliance with the limits of I.B.1.

3. The number of piping circumferential and longitudinal welds and branch connections should be minimized.

4. The length of the piping run should be reduced to the minimum length practical.

5. The design at points of pipe fixity (e.g., pipe anchors or welded connections at containment penetrations) should not require welding directly to the outer surface of the piping (e.g., fluid integral forged pipe fittings may be used) except where detailed stress analyses are performed to demonstrate compliance with the limits of I.B.1.

6. Geometric discontinuities, such as at pipe-to-valve section transitions, at branch connections, and at changes in pipe wall thickness should be designed to minimize the discontinuity stresses.

C. *Fluid Systems* Enclosed Within Protective Structures

1. Breaks in ASME Code, Section III, Class 2 and 3 piping should

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[2/] The limit of $0.8(1.2\ S_h + S_A)$ may be used in lieu of $(S_c + S_h)$.

be postulated at the following locations in each piping and branch run (except those portions of *fluid system* piping identified in I.B.) within a protective structure containing *essential systems and components* and designed to satisfy the provisions of 1.b. or 1.c. of Appendix A:

a. At *terminal ends* of the pressurized portions of the run if located within the protective structure.

b. At intermediate locations selected by either of the following criteria:

(i) At each pipe fitting (e.g., elbow, tee, cross, and non-standard fitting) or, if the run contains no fittings, at one location at each extreme of the run (a *terminal end*, if located within the protective structure may substitute for one intermediate break).

(ii) At each location where the stresses[3/] exceed $(S_h + S_c)$[2/] but at not less than two separated locations chosen on the basis of highest stress[4/]. In the case of a straight pipe run without any pipe fittings or welded attachments and stresses below $(S_h + S_c)$, a minimum of one location chosen on the basis of highest stress.

[3/] Stresses associated with *normal* and *upset plant conditions*, and an OBE event as calculated by Eq. (9) and (10), Par. NC-3652 of the ASME Code, Section III, for Class 2 and 3 piping

[4/] Two highest stress points; select second point at least 10% below the highest stress.

2. Breaks in non-nuclear class piping should be postulated at the following locations in each piping or branch run:

   a. At *terminal ends* of the pressurized portions of the run if located within the protective structure.

   b. At each intermediate pipe fitting and welded attachment.

D. *Fluid Systems* Not Enclosed Within Protective Structures

1. Breaks in ASME Code, Section III, Class 2 and 3 piping, should be postulated at the following locations in each piping and branch run (except those portions of *fluid system* piping identified in I.B) outside but routed alongside, above, or below a protective structure containing *essential systems and components* and designed to satisfy the provisions of 1.b, or 1.c of Appendix A.

   a. At *terminal ends* of pressurized portions of the run if located adjacent to the protective structure.

   b. At intermediate locations selected by either of the following criteria:

      (i) At each pipe fitting (e.g., elbow, tee, cross, and non-standard fitting).

      (ii) At each location where the stresses[3/] exceed $(S_h + S_c)$[2/] but at not less than two separated locations chosen on the basis of highest stress[4/]. In the case of a straight pipe run without any pipe fittings or welded attachments and stresses below ($S_h + S_c$), a minimum of one location chosen on the basis of highest stress.

2. Breaks in non-nuclear class piping should be postulated at the following locations in each piping or branch run:

   a. At terminal ends of pressurized portions of the run if located adjacent to the protective structure.

   b. At each intermediate pipe fitting and welded attachment.

II. *Moderate-Energy Fluid System Piping*

A. *Fluid Systems* Separated from *Essential Structures, Systems & Components*

For the purpose of satisfying the separation provisions of 1.a. of Appendix A, a review of the piping layout and plant arrangement drawings should clearly show that the effects of through-wall leakage cracks at any location are isolated or physically remote from *essential structures, systems, and components.*

B. *Fluid System* Piping Between Containment Isolation Valves

Breaks need not be postulated in those portions of piping identified in 2.c. of Appendix A provided they meet the requirements of ASME Code, Section III - Subarticle NE-1110, and are designed such that the stresses do not exceed $0.5(S_h + S_c)$[5] for ASME Code, Section III, Class 2 piping.

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[5] The [illegible]

C. *Fluid Systems* Within or Outside and Adjacent to Protective Structures

Through-wall leakage cracks should be postulated in *fluid system* piping located within or outside and adjacent to protective structures containing *essential systems and components* and designed to satisfy the provisions of 1.b. or 1.c. of Appendix A, except where exempted by II.B, II.D, or in those portions of ASME Code, Section III, Class 2 or 3 piping or non-nuclear piping where the stresses are less than $0.5(S_h + S_c)$[5/]. The cracks should be postulated to occur individually at locations that result in the maximum effects from fluid spraying and flooding, and the consequent hazards or environmental conditions developed.

D. *Moderate-Energy Fluid Systems* in Proximity to *High-Energy Fluid Systems*

Cracks need not be postulated in *moderate-energy fluid system* piping located in an area in which a break in *high-energy fluid system* piping is postulated, provided such cracks would not result in more limiting environmental conditions than the high-energy piping break. Where a postulated leakage crack in the *moderate-energy fluid system* piping results in more limiting environmental conditions than the break in proximate *high-energy fluid system* piping, the provisions of II.C should be applied.

E. *Fluid Systems* Qualifying as *High-Energy* or *Moderate-Energy Systems*

Through-wall leakage cracks instead of breaks may be postulated in the piping of those *fluid systems* that qualify as *high energy fluid systems* for only short operational periods[6/] but qualify as *moderate-energy fluid systems* for the major operational period.

III. Type of Breaks and Leakage Cracks in *Fluid System* Piping

A. Circumferential Pipe Breaks

The following circumferential breaks should be postulated in *high-energy fluid system* piping at the locations specified in Section I above:

1. Circumferential breaks should be postulated in *fluid system* piping and branch runs exceeding a nominal pipe size of 1 inch, except that, if the maximum stress range in the circumferential direction is at least twice that in the axial direction, only a longitudinal break need be postulated. Instrument lines, one inch and less nominal pipe size for tubing should meet the provisions of Regulatory Guide 1.11.

2. Where break locations are selected at pipe fittings without the benefit of stress calculations, breaks should be postulated at each pipe-to-fitting weld. If detailed stress analyses

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[6/] An operational period is considered "short" if the fraction of time that the system operates within the pressure-temperature conditions specified for *high-energy fluid systems* is less than 2 percent of the time that the system operates as a *moderate energy fluid system* (e.g., systems such as the reactor decay heat removal systems qualify as *moderate-energy fluid systems*; however, systems such as auxiliary feedwater systems operated during PWR reactor startup, hot standby, or shutdown qualify as *high-energy fluid systems*).

(e.g., finite element analyses) or tests are performed, the maximum stressed location in the fitting may be selected instead of the pipe-to-fitting weld.

3. Circumferential breaks should be assumed to result in pipe severance and separation amounting to a one-diameter lateral displacement of the ruptured piping sections unless physically limited by piping restraints, structural members, or piping stiffness as may be demonstrated by inelastic limit analysis (e.g., a plastic hinge in the piping is not developed under loading).

4. The dynamic force of the jet discharge at the break location should be based on the effective cross-sectional flow area of the pipe and on a calculated fluid pressure as modified by an analytically or experimentally determined thrust coefficient. Limited pipe displacement at the break location, line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge.

5. Pipe whipping should be assumed to occur in the plane defined by the piping geometry and configuration, and to cause pipe movement in the direction of the jet reaction.

B. Longitudinal Pipe Breaks

The following longitudinal breaks should be postulated in *high-energy fluid system* piping at the locations of each circumferential break specified in III.A.:

1. Longitudinal break in *fluid system* piping and branch runs should be postulated in nominal pipe sizes 4-inch and larger, except that, if the maximum stress range in the axial direction is at least twice that in the circumferential direction, only a circumferential break need be postulated.

2. Longitudinal breaks need not be postulated at *terminal ends* if the piping at the *terminal ends* contains no longitudinal pipe welds and major geometric discontinuities at the circumferential weld joints of the *terminal ends* are designed to minimize discontinuity stresses.

3. Longitudinal breaks should be assumed to result in an axial split without pipe severance. Splits should be located (but not concurrently) at two diametrically-opposed points on the piping circumference such that a jet reaction causing out-of-plane bending of the piping configuration results.

4. The dynamic force of the fluid jet discharge should be based on a circular or elliptical (2D x 1/2D) break area equal to the effective cross-sectional flow area of the pipe at the break location and on a calculated fluid pressure modified by an analytically or experimentally determined thrust coefficient as determined for a circumferential break at the same location. Line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge.

5. Piping movement should be assumed to occur in the direction of the jet reaction unless limited by structural members, piping restraints, or piping stiffness as demonstrated by inelastic limit analysis.

C. Through-Wall Leakage Cracks

The following through-wall leakage cracks should be postulated in *moderate-energy fluid system* piping at the locations specified in Section II above:

1. Cracks should be postulated in *moderate-energy fluid system* piping and branch runs exceeding a nominal pipe size of 1 inch.

2. Fluid flow from a crack should be based on a circular opening of area equal to that of a rectangle one-half pipe-diameter in length and one-half pipe wall thickness in width.

3. The flow from the crack should be assumed to result in an environment that wets all unprotected components within the compartment, with consequent flooding in the compartment and communicating compartments. Flooding effects may be determined on the basis of a conservatively-estimated time period required to effect corrective actions.

APPENDIX A

PLANT ARRANGEMENT CRITERIA AND SELECTED PIPING DESIGN FEATURES

1. Plant Arrangement

Protection of *essential structures, systems, and components* 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 one of the following plant arrangement considerations:

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

b. *Fluid system* piping or portions thereof not satisfying the provisions of 1.a. above should be enclosed within structures or compartments designed to protect nearby *essential structures, 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 1.a. or 1.b. above should be limited to those for which the above provisions are impractical. 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 such cases, redundant design features, separated or otherwise protected from effects of *postulated piping failures*, or additional protection should be provided so that reactor shutdown is assured in the event of a failure in the interconnecting piping of (1), or in the dual function piping of (2). 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*.

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 1.b. or 1.c. above should be designed to Seismic Category I requirements. The effects of a *postulated piping failure* (i.e., pipe whip, jet impingement, pressurization of compartment, water spray, and flooding, as appropriate) in combination with loadings associated with the Safe Shutdown Earthquake and normal operation should be used for the design of required protective 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 the effects of a postulated break[1/] in one pipe cannot, in turn, rupture other nearby pipes or components which could result in unacceptable offsite consequences or in loss of capability of *essential systems and components* to initiate, actuate, and complete actions required for reactor shutdown.

c. *Fluid system* piping between containment isolation valves should meet the following design provisions:

[1/] In the design of piping restraint, an unrestrained whipping pipe should be considered capable of (a) rupturing impacted pipes of smaller nominal pipe sizes and (b) developing a through-wall leakage crack in larger nominal pipe sizes with thinner wall thicknesses except where experimental or analytical data for specific impact energies demonstrate the capability to withstand the impact without failure.

(1) Portions of *fluid system* piping between isolation valves of single barrier containment structures (including any rigid connection to the containment penetration) that connect, on a continuous or intermittent basis to the reactor coolant pressure boundary or the steam and feedwater systems of PWR plants should be designed to the stress limits specified in I.B. or II.B. of this document.

These portions of *high-energy fluid system* piping should be provided with pipe whip restraints (i.e., capable of resisting bending and torsional moments) located reasonably close to the containment isolation valves. The restraints should be designed to withstand the loadings resulting from a *postulated piping failure* beyond these portions of piping so that neither isolation valve operability nor the leaktight integrity of the containment will be impaired.

Terminal ends of the piping runs outside containment should be considered to originate at the pipe whip restraint locations outside containment.

Where containment isolation valves are not required inside containment, those portions of the fluid system piping extending from the outside isolation valve to either the rigid pipe connection to the containment penetration or the first pipe whip restraint inside containment should be considered as the boundary of the system piping required to meet the above design limits and restraint provisions.

(2) Portions of *fluid system* piping between isolation valves of dual barrier containment structures should not exceed the stress limits in I.B. or II.B. of this document. These portions of high-energy fluid system piping that pass through the annulus, and whose failure could affect the leaktight integrity of the containment structure or result in pressurization of the annulus beyond design limits, should be provided with pipe whip restraints (i.e., capable of resisting bending and torsional moments) located reasonably close to the containment isolation valves and should be provided with an enclosing structure or guard pipe. Restraints should be designed to withstand the loadings resulting from a *postulated piping failure* beyond these portions of piping so that neither isolation valve operability nor the leaktight integrity of the associated containment penetration will be impaired.

Terminal ends of the piping runs outside containment should be considered to originate at the pipe whip restraint locations outside containment.

For the purpose of establishing the design parameters (e.g., pressure, temperature, axial loads) only of the enclosing structure or guard pipe, a full flow area break should be assumed in that portion of piping within the enclosing structure or guard pipe.

(3) For those portions of *fluid system* piping identified in 2.c.(1) and 2.c.(2) above, the extent of inservice examination conducted as specified in Division 1 of Section XI of the ASME Code during each inspection interval should be increased to provide volumetric examination of 100 percent of the circumferential and longitudinal weld joints in piping identified in Section III.A.1. and Section III.B.1. of this document. The areas subject to examination should comply with the requirements of the following categories as specified in Section XI of the ASME Code:

(a) ASME Class 1 piping welds, Examination Category B-J in Table IWB-2500.

(b) ASME Class 2 piping welds, Examination Category C-F and C-G in Table IWC-2500.

GLOSSARY

Essential Structures, Systems, and Components. Structures, systems, and components required for reactor shutdown without off-site power or to mitigate the consequences of a *postulated piping failure* in *fluid system* piping that results in trip of the turbine-generator or the reactor protection system.

Fluid Systems. *High and moderate energy fluid systems* that are subject to the postulation of piping failures against which protection of *essential structures, 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 200°F, or

b. maximum operating pressure exceeds 275 psig.

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 200°F or less, and

b. maximum operating pressure is 275 psig 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 this document.

S_h, S_c, and S_A. Allowable stresses at maximum (hot) temperature, at minimum (cold) temperature, and allowable stress range for thermal expansion respectively, as defined in Article NC-3600 of the ASME Code, Section III.

S_m. Design stress intensity as defined in Article NB-3600 of the ASME Code, Section III.

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.

Terminal Ends. Extremeties of piping runs that connect to structures, components (e.g., vessels, pumps, valves), or pipe anchors that act as rigid constraints to piping thermal expansion. A branch connection to a main piping run is a terminal end of the branch run.

Attachment B

ELECTRICAL AND MECHANICAL EQUIPMENT SEISMIC QUALIFICATION PROGRAM

I. Seismic Test for Equipment Operability

1. A test program is required to confirm the functional operability of all Seismic Category I electrical and mechanical equipment and instrumentation during and after an earthquake of magnitude up to and including the SSE. Analysis without testing may be acceptable only if structural integrity alone can assure the design intended function. When a complete seismic testing is impracticable, a combination of test and analysis may be acceptable.

2. The characteristics of the required input motion should be specified by one of the following:

   (a) response spectrum
   (b) power spectral density function
   (c) time history

   Such characteristics, as derived from the structures or systems seismic analysis, should be representative of the input motion at the equipment mounting locations.

3. Equipment should be tested in the operational condition. Operability should be verified during and after the testing.

4. The actual input motion should be characterized in the same manner as the required input motion, and the conservatism in amplitude and frequency content should be demonstrated.

5. Seismic excitation generally have a broad frequency content. Random vibration input motion should be used. However, single frequency input, such as sine beats, may be applicable provided one of the following conditions are met:

   (a) The characteristics of the required input motion indicate that the motion is dominated by one frequency (i.e., by structural filtering effects).

   (b) The anticipated response of the equipment is adequately represented by one mode.

   (c) The input has sufficient intensity and duration to excite all modes to the required magnitude, such that the testing response spectra will envelope the corresponding response spectra of the individual modes.

6. The input motion should be applied to one vertical and one principal (or two orthogonal) horizontal axes simultaneously unless it can be demonstrated that the equipment response along the vertical direction is not sensitive to the vibratory motion along the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear resultant input is avoided. The acceptable alternative is to have vertical and horizontal inputs in-phase, and then repeated with inputs 180 degrees out-of-phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.

7. The fixture design should meet the following requirements:

   (a) Simulate the actual service mounting
   (b) Cause no dynamic coupling to the test item.

8. The in-situ application of vibratory devices to superimpose the seismic vibratory loadings on the complex active device for operability testing is acceptable when application is justifiable.

9. The test program may be based upon selectively testing a representative number of mechanical components according to type, load level, size, etc. on a prototype basis.

II. <u>Seismic Design Adequacy of Supports</u>

1. Analyses or tests should be performed for all supports of electrical and mechanical equipment and instrumentation to ensure their structural capability to withstand seismic excitation.

2. The analytical results must include the following:

   (a) The required input motions to the mounted equipment should be obtained and characterized in the manner as stated in Section I.2.

   (b) The combined stresses of the support structures should be within the limits of ASME Section III, Subsection NF - "Component Support Structures" (draft version) or other comparable stress limits.

3. Supports should be tested with equipment installed. If the equipment is inoperative during the support test, the response at the equipment mounting locations should be monitored and characterized in the manner as stated in Section I.2. In such a case, equipment should be tested separately and the actual input to the equipment should be more conservative in amplitude and frequency content than the monitored response.

4. The requirements of Sections I.2, I.4, I.5, I.6 and I.7 are applicable when tests are conducted on the equipment supports.