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September 15, 1986
ST-HL-AE-1745
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X01.03/MC9

Mr. Vincent S. Noonan, Project Director
PWR Project Directorate #5
U. S. Nuclear Regulatory Commission
Washington, DC 20555

South Texas Project
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Additional Annotated FSAR Changes
Concerning Section 3.6, Pipe Break Criteria

References:
(1) NRC Letter to HL&P, T.M Novak to J. H. Goldberg, August 11, 1985, ST-AE-HL-90682
(2) HL&P Letter to NRC, M. R. Wisenburg to H. L. Thompson, Jr., February 28, 1986, ST-HL-AE-1611
(3) HL&P Letter to NRC, M. R. Wisenburg to V. S. Noonan, May 2, 1986, ST-HL-AE-1656
(4) HL&P Letter to NRC, M. R. Wisenburg to V. S. Noonan, August 14, 1986, ST-HL-AE-1722
(5) HL&P Letter to NRC, M. R. Wisenburg to V. S. Noonan, August 28, 1986, ST-HL-AE-1723

Dear Mr. Noonan:

Attached are additional annotated changes to the South Texas Project (STP) FSAR Section 3.6 concerning pipe break criteria. These changes incorporate the changes previously identified to the NRC in references (2) through (5). Additionally, other changes are included in order to bring the FSAR up to date with the current design philosophy on pipe break criteria. These changes will be incorporated to the STP FSAR in a future amendment. It is recommended that these changes be reviewed concurrently with the FSAR changes concerning the rule change to GDC-4 (reference ST-HL-AE-1744).

In addition, the attachment contains changes previously transmitted to the NRC via reference (3). Verbal comments from the staff have been incorporated and these changes are being included for completeness.

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If you should have any questions on this matter, please contact Mr. M. E. Powell at (713) 993-1328.

Very truly yours,

M. R. Wisenburg
Manager, Nuclear Licensing

MEP/yd

Attachment: Annotated changes to FSAR Section 3.6 and Q210.19N

L1/NRC/bc

cc:

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The use of nonseismic Category I ~~piping~~ SYSTEMS in mitigating the consequence of postulated piping failure (OTHER THAN A MAIN STEAM SYSTEM PIPING FAILURE) outside the containment is clarified in the following paragraphs:

1. For nonseismic Category I piping failures, it is assumed that a safe shutdown earthquake could be the cause of the failure. Therefore, only seismic Category I equipment can be used to mitigate the consequences of the failure and bring the plant to a safe shutdown. 53

2. A postulated failure in seismically qualified portions of piping systems is not assumed to be seismically induced. Propagation of the failure to failures on nonseismically qualified equipment is not assumed. ~~Only safety grade equipment is considered in satisfying protection criteria. However, credit is taken for the use on nonsafety grade equipment as backup for random single failures.~~ NON-SEISMIC CATEGORY I EQUIPMENT CAN BE USED TO BRING THE PLANT TO A SAFE SHUTDOWN FOLLOWING A POSTULATED FAILURE IN SEISMICALLY QUALIFIED PIPING, SUBJECT TO POWER BEING AVAILABLE TO OPERATE SUCH EQUIPMENT AND PROVIDING THE EQUIPMENT IS QUALIFIED FOR THE ENVIRONMENT RESULTING FROM THE PIPING FAILURE.

Question 210.19N

Provide assurance that the guidance stated in BTP MEB 3-1, Section B.1.C. (1) (d) (iii) concerning changes of new highest stress locations as a result of piping reanalysis has been used in STP high energy line break location postulation.

Response

BTP MEB 3-1, Section B.1.C(1)(d)(iii) is complied with to the extent that new high stress locations exceeding the break location criteria described below are considered as break locations regardless of the degree of remoteness from previous high stress points.

Section 3.6.2.1.1 specifies the criteria for postulating pipe break locations. It states that breaks are postulated at terminal ends and at intermediate locations based on stresses and cumulative usage factors. Arbitrary intermediate breaks are not postulated in high energy piping in accordance with the letters to the NRC ST-HL-AE-1115 dated August 20, 1984, ~~and~~ ST-HL-AE-1202 dated March 8, 1985, and ST-HL-AE-1723 dated August 28, 1986. Section 3.6.2.1.1.2, Tables 3.6.1-2, 3.6.1-3, and 3.6.2-1 have been revised to reflect elimination of arbitrary intermediate breaks in HE piping.

As the stress analysis is finalized, it is anticipated that changes in intermediate break locations, if any, would be due to the criterion contained in BTP MEB 3-1, Section B.1.C(1)(d) (i) and (ii) and thus enveloping criterion B.1.C(1)(d) (iii).

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Question 210.29N

Provide the loads, load combinations, and stress limits that were used in the design of pipe rupture restraints. Include a discussion of the design methods applicable to the auxiliary steel used to support the pipe rupture restraint. Provide assurance that the pipe rupture restraint and supporting structure cannot fail during a seismic event.

Response

Refer to the last paragraph of the response to Question 210.20N. RCL pipe breaks have been eliminated thereby eliminating the need for RCS loop restraints.

Pipe whip restraints for other than the RCL are designed as a combination of an energy-absorbing element (EAE) and a supporting (auxiliary) structure capable of transmitting the resistance load from the EAE to the main building structures (concrete walls, slabs, and steel structures). The EAE usually is either thin gauge cellular crushable material (energy-absorbing material, (EAM)) or stainless steel U-bars. The design limits for EAEs are specified in Section 3.6.2.3.4.1.2.

INSERT 1

The supporting structures ~~typically~~ are ~~structural steel frames~~ designed to the loads, load combinations, and stress limits as specified in Section 3.8.3.3 and Tables 3.8.3-2 and 3.8.4-2. ~~Except for the main steam restraints inside the containment, the elastic working stress design method of Part I of the AISC specification 1969 (including supplements 1, 2 and 3) is used. The main steam line restraints inside the containment are designed using a non-linear method, with allowable ductilities per Section 3.5.3 and Table 3.5-13, where the ultimate strain is taken as 50 percent of ASTM specified minimum.~~

Both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) seismic events are specifically included in the loading combinations prescribed for the structural integrity of the pipe whip restraints. The restraints and their structures are treated as structural subsystems whose seismic response is determined from their frequency characteristics and the appropriate floor response spectra. INSERT 2

INSERT

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INSERT 1

For supporting structures designed to respond elastically, stress limits are set in accordance with Part I of the AISC specification with stress increase factors as given under the STRENGTH heading of Tables 3.8.3-2 and 3.8.4-2. Alternatively, supporting structures may be designed to respond inelastically as stated in Note (f) of the Tables 3.8.3-2 and 3.8.4-2. In this case, the design is limited by the ductility ratios given in Tables 3.5-13, items 5, 6 and 7.

INSERT 2

In all cases, the design for load components due to seismic response is subject to stress limits set in accordance with Part I of the AISC specification as described above. For the cases where pipe rupture loads force the structure into the inelastic range and the SSE loading is a non-governing component, the stress limits are not applicable and the ductility factors as described above are used to control the design.

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8. All available systems, including those actuated by operator actions, are employed to mitigate the consequences of a postulated piping failure to the extent clarified in the following paragraphs:

   a. In determining the availability of the systems, account is taken of the postulated failure and its direct consequences, such as unit trip and LOOP, and of the assumed single active component failure and its direct consequences. The feasibility of carrying out operator actions is determined on the basis of ample time and adequate access to equipment being available for the proposed actions. Although a postulated high/moderate-energy line failure outside the containment may ultimately require a cold shutdown, operation at hot standby is allowed in order for plant personnel to assess the situation and make repairs.

   b. The use of non-seismic Category I ~~piping~~ SYSTEMS in mitigating the consequence of postulated piping failure (OTHER THAN A MAIN STEAM SYSTEM PIPING FAILURE) outside the containment is clarified in the following paragraphs:

      1) For non-seismic Category I piping failures, it is assumed that a safe shutdown earthquake could be the cause of the failure. Therefore, only seismic Category I equipment can be used to mitigate the consequences of the failure and bring the plant to a safe shutdown. 40

      2) A postulated failure in seismically qualified portions of piping systems is not assumed to be seismically induced. Propagation of the failure to failures of non-seismically qualified equipment is not assumed. ~~Only safety grade equipment is considered in satisfying protection criteria. However, credit is taken for the use of non-safety grade equipment as backup for random single failures.~~ INSERT 1

9. A whipping pi is not considered capable of rupturing impacted pipes of equal or greate nominal pipe diameter and equal or greater wall thickness.

   A whipping pipe is considered capable of developing a through-wall leakage crack in a pipe of larger nominal pipe size with thinner wall thickness.

   INSERT 2

10. Pipe whip is assumed to occur in the plane defined by the initial axis of the jet thrust force and a plastic hinge point.

   If unrestrained, a whipping pipe having a JET THRUST FORCE ~~constant energy source~~ sufficient to form a plastic hinge is considered to ~~form a plastic hinge and~~ rotate about the plastic hinge point ~~nearest rigid pipe whip restraint, anchor, or wall penetration capable of resisting the pipe whip loads. If the direction of the initial pipe movement caused by the thrust force is such that~~ the whipping pipe will continue in motion until it is stopped by a structure or component of SUFFICIENT STRENGTH TO WITHSTAND THE LOADING IMPOSED BY THE WHIPPING PIPE. ~~impacts a flat surface normal to its direction of travel, it is assumed that the pipe comes to rest against that surface, with no pipe whip in other directions.~~

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Page 3.6-3

Insert 1

Non-seismic Category I equipment can be used to bring the plant to a safe shutdown following a postulated failure in seismically qualified piping, subject to power being available to operate such equipment and providing the equipment is qualified for the environment resulting from the piping failure.

Insert 2

Impact against rigid steel electrical conduit, whose nominal pipe size and wall thickness are equal to or greater than those of the whipping pipe, is not assumed to damage the impacted conduit. If the conduit size is smaller than that of the whipping pipe, the conduit damage threshold is taken to be exceeded and cables within are assumed to fail.

In general, whipping ends from a pipe break are restrained so that plastic hinge formation is not allowed to occur. Where a plastic hinge could be formed, the effects are evaluated. Pipe whip restraints are provided wherever postulated pipe breaks could impair the ability of any essential system or component to perform its intended safety functions listed in Section 3.6.1.1.

11. The calculation of thrust and jet impingement forces considers any line restrictions (e.g., flow limiter) between the pressure source and break location and the absence of energy reservoirs, as applicable.

12. Initial pipe break events ~~were~~ ARE not assumed to occur in pump and valve bodies because of their greater wall thickness and their usual location in the low stress portions of the piping systems.

13. Where a system consisting of piping, restraints, and supporting structures is so complex that the assumption of planar motion is neither conservative nor realistic, the zone of whip influence is conservatively enlarged to a region approaching a sphere with a radius equal to the distance between the breakpoint and the first restraint. In lieu of this assumption a more detailed elastoplastic analysis is performed.

14. No loss of pressure boundary integrity is assumed from jet impingement, regardless of pressure, when the ruptured pipe has a diameter and wall thickness less than those of the impinged piping. For essential piping, jet impingement loads are evaluated regardless of the ratio of impinged and postulated broken pipe sizes. 40 50 Q210.23N

→ INSERT

3.6.1.2 Description. Systems, components, and equipment required to perform the essential functions are reviewed to ensure conformance with the design bases and to determine their susceptibility to the failure effects. The break and crack locations are determined in accordance with Section 3.6.2. Figure 3.6.1-1 shows the high-energy pipe break locations, break types, and preliminary restraint locations.

A design comparison to NRC BTP ASB 3-1 and MEB 3-1 is provided in Tables 3.6.1-2 and 3.6.1-3.

Pressure response analyses are performed for subcompartments containing high-energy piping. For a detailed discussion of the pipe breaks selected and pressure results, refer to Section 6.2.1 for selected subcompartments inside the Containment and to Appendix 3.6A for selected subcompartments outside the Containment. Effects of ~~both~~ internal reactor pressure vessel asymmetric pressurization loads ARE ADDRESSED IN SECTION 3.9.2. ~~and~~ Asymmetric compartment pressurization loads inside Containment are addressed in Section 6.2.1. The analytical methods used for pressure response analysis are in accordance with Reference 3.6-2. 53 53

There are no high-energy lines in the proximity of the control room; therefore, there are no effects upon the habitability of the control room resulting from postulated pipe breaks. Further discussion of the control room habitability systems is provided in Section 6.4.

INSERT

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15. Components impacted by jets from breaks in piping containing high pressure (870 to 2465 psia) steam or subcooled liquid that flashes at the break, such as piping connected to the steam generators or reactor coolant loops, shall be evaluated as follows:

   A. Unprotected components within 10 diameters (ID) of the broken pipe are assumed to fail. Specific jet loads are calculated and evaluated only when failure of the component, when combined with a single active failure, could adversely affect safe shutdown capability. These jet load calculations will be performed in accordance with Section 3.6.2.3.1.

   B. Unprotected components beyond 10 diameters (ID) of the broken pipe are considered undamaged by the jet without further analysis. The basis for this criteria is contained in Reference 3.6-13.

3.6.1.3 Safety Evaluation.

3.6.1.3.1 General: An analysis of postulated pipe failures is performed to determine the impact of such piping failures on those safety-related systems or components which are required to mitigate the consequences of the failure. By means of protective measures, such as separation, barriers, and pipe whip restraints, the effects of breaks and cracks are prevented from damaging essential items to an extent that would impair their essential function or necessary component operability. Typical measures used for protecting the essential systems, components, and equipment are outlined below and are discussed in detail in Section 3.6.2. The ability of specific safety-related systems to withstand a single active failure concurrent with the postulated event is discussed, as applicable. When the results of the pipe failure effects analysis show that the effects of a postulated pipe failure are isolated, physically remote, or restrained by protective measures from essential systems or components, no further dynamic hazards analysis is performed.

3.6.1.3.2 Protection Mechanisms: The plant layout arrangement is based on maximizing the physical separation of redundant or diverse safety-related components and systems from each other and from nonsafety-related items. Therefore, in the event a pipe failure occurs, there is a minimal effect on other essential systems or components required for safe shutdown of the plant or to mitigate the consequences of the failure.

The effects associated with a particular pipe failure must be mechanistically consistent with the failure. Thus, pipe dimensions, pipe layouts, material properties, and equipment arrangements are considered in defining the specific measures for protection against the consequences of postulated failures. 40

Protection against the dynamic effects of pipe failures is provided in the form of physical separation of systems and components, barriers, equipment shields, and pipe whip restraints. The precise method chosen depends largely upon considerations such as accessibility and maintenance.

1. Separation

   The plant arrangement provides separation, to the extent practicable, between redundant safety systems (including their appurtenances) to prevent loss of safety function as a result of hazards for which the system is required to be functional. Separation between redundant safety systems, with their related appurtenances, therefore, is the basic protective measure incorporated in the design to protect against the dynamic effects of postulated pipe failures.

   In general, layout of the facility follows a multi-step process to ensure adequate separation:

   a. Safety-related systems are located remotely from high-energy piping, where practicable.

   b. Redundant safety systems are located in separate compartments.

   c. As necessary, specific components are enclosed to retain the redundancy required for those systems that must function as a consequence of specific piping failure.

NO CHANGE

d. Drainage systems are reviewed to ensure their adequacy for flooding control.

2. Barriers and Shields

Protection requirements are met through the protection afforded by walls, floors, columns, abutments, and foundations. Where adequate protection does not already exist as a result of separation, additional barriers, deflectors, or shields are provided to meet the functional protection requirements.

Inside the containment, the secondary shield wall serves as a barrier between the reactor coolant loops and the containment liner. In addition, the refueling cavity walls, operating floor, and secondary shield walls minimize the possibility of an accident which may occur in any one reactor coolant loop affecting another loop or the containment liner. Those portions of the steam and feedwater lines located within the Containment are routed in such a manner that possible interaction between these lines and the reactor coolant piping is minimized. The barriers withstand loadings caused by jet forces and pipe whip impact forces.

Further discussion of barriers and shields is provided in Section 3.6.2.4.

3. Piping Restraint Protection 40

Measures for protection against pipe whip are provided where the unrestrained pipe movement of the ruptured pipe could cause damage at an unacceptable level to any structure, system, or component required to meet the criteria outlined in Section 3.6.1.1.

The design criteria for and description of pipe whip restraints are given in Section 3.6.2.3.

3.6.1.3.3 Specific Protection Considerations:

1. EXCEPT FOR A MAIN STEAM SYSTEM PIPING FAILURES, ~~N~~onessential systems, structures and components are ~~only~~ used to mitigate ~~random single failures following~~ THE CONSEQUENCES OF a postulated pipe rupture (See Section 3.6.1.1.8).

2. High-energy containment penetrations are subject to special protection mechanisms. As discussed in Section 3.6.2.1.1.5, isolation restraints are located as close as practical to the containment isolation valves associated with these penetrations. These restraints are provided, as appropriate, to maintain the operability of the isolation valves and the integrity of the penetration due to a break either upstream or downstream of the respective isolation restraints.

3. SAFETY RELATED ~~I~~nstrumentation that is required to MITIGATE THE EFFECTS OF THE ~~function following a~~ pipe rupture is protected.

4. High-energy fluid system pipe whip restraints and protective measures are designed so that a postulated break in one pipe cannot, in turn, lead to a rupture of other essential pipes or components.

3.6.2.1.1 <u>High-Energy Break Locations</u>: With the exception of those portions of the piping identified in Section 3.6.2.1.1.5, breaks are postulated in high-energy piping at the following locations:

1. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section III, Division 1 - Class 1 Piping.

   a. The discrete break locations and orientations in the RCL are derived on the basis of stress and fatigue analysis. These postulated break locations and the methods used to determine them are described in Ref. 3.6-1. An analysis of each individual RCL confirms the break locations defined in Ref. 3.6-1. The stresses and cumulative usage factors resulting from seismic events are included in the stresses and cumulative usage factors which are discussed in Section 3.6.2.5 to verify the design basis break locations in the RCL noted therein. 40

      At postulated circumferential break locations, the piping is assumed to separate to allow double-ended flow unless structural restraints exist which physically limit the break opening area. As an example, for the reactor coolant pipe break at the reactor vessel nozzle, the pipe will be restrained, preventing the development of a full double-ended break. At other locations where a reduced break area is used primarily due to structural steel or concrete restraints, justification is provided in Section 3.6.2.5. Longitudinal breaks are assumed to have an opening area equal to the flow area of the pipe. 45

   b. Pipe breaks are postulated to occur at the following locations in ASME Code Section III Class 1 piping runs or branch runs outside the RCL as follows:

      1) At terminal ends of the piping, including:

         a) Piping connected to structures, components, or anchors that act as essentially rigid restraints to piping translation and rotational motion due to static or dynamic loading. 40

         b) High/moderate-energy boundary such as piping runs which are maintained pressurized during normal plant conditions for only a portion of the run, i.e., up to the first normally closed valve. The terminal end of such piping is the piping connection to the closed valve.

         c) INSERT ~~B~~ Branch intersection points are considered a terminal end for the branch line except (1) where the branch and the main piping systems are modeled in the same piping stress analysis and the branch line is shown to have a significant effect on the main run behavior (i.e., the nominal size of the branch line is at least one-half of that of the main or the ratio of the moment of inertia of main run pipe to the branch line is less than 10) or (2) where, regardless of size or moment of inertia ratio, the branch lines are short in length and have no significant restraint due to thermal expansion. 40 Q110.6 50 Q110.6

INSERT

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Twelve inch (12") and larger piping connected to the RCL may be modeled with the RCL in the same piping analysis and, therefore, considered a part of the main run. Other

2) At intermediate locations where the following conditions are satisfied.

a) The maximum stress range between any two load sets, derived on an elastically calculated basis by Equation (10) and either Equations (12) or (13) of subarticle NB-3653 of ASME Code Section III, under loadings associated with the OBE and normal and upset plant conditions, exceeds 2.4 S_m, or 40

b) The cumulative usage factor exceeds 0.1.

INSERT C

3) ~~As a result of piping reanalysis, the highest stress locations may be shifted. However, once a high energy piping system has been analyzed and break locations have been identified and evaluated, the original break locations are not changed unless one of the following conditions exist:~~ 45 40

a) ~~Maximum stress ranges or cumulative usage factors exceed the threshold levels specified in 2) a) and 2) b) above;~~

b) ~~A change is required in pipe parameters such as major differences in pipe size, wall thickness, and routing.~~ 5

2. ASME Code Section III Class 2 and 3 piping, breaks are postulated to occur at the following locations in each run or branch run: 40

a. The terminal ends.

b. At all intermediate locations between terminal ends where the primary plus secondary stresses under normal and upset conditions and an OBE event, as calculated on an elastic basis by the sum of Equations (9) and (10) (subarticle NC-3652 of the ASME Code, Section III), exceed 0.8 $(1.2S_H + S_A)$.

c. ~~As a result of piping reanalysis, the highest stress locations may be shifted. However, once a high-energy piping system has been analyzed and break locations have been identified and evaluated, the original intermediate break locations are not changed unless one of the following conditions exist:~~ 53 53

1) ~~Maximum stresses exceed the threshold level specified in 2.b above.~~

2) ~~A change is required in pipe parameters such as major differences in pipe size, wall thickness, and routing.~~ 40

3. System Where a Combination of ASME Code Section III Class 1 and Class 2 High-energy Piping Exists

In cases where both ASME Code Class 1 and Class 2 piping exist between terminal ends, the following apply:

a. If the stress levels and the cumulative usage factor in the ASME Code Class 1 portion and the stress levels in the Class 2 portion

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...except for butt welded austenitic stainless steel piping where process fluid oxygen content is controlled as described in Section 5.2.3.2.1. Breaks are postulated in such piping where the cumulative usage factor exceeds 0.4.

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exceed the limits specified in 1. and 2. above, then the breaks are postulated at each of these locations. 45

~~b. As a result of piping reanalysis, the highest stress locations may be shifted. However, the original break locations may be used unless one of the appropriate conditions of 1.b.2) above for the Class 1 portion or 2.c for the Class 2 portion exist.~~ 40 45

4. Non-nuclear High-energy Piping

a. Breaks are postulated to occur in non-nuclear piping in the same manner as specified for ASME Code Section III Class 2 and 3 piping if the non-nuclear piping is analyzed and supported to withstand Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) loadings. 40 Q110.07

b. In the absence of a dynamic seismic analysis, breaks in non-nuclear piping are postulated at the following locations in each run or branch run:

1) Terminal ends

2) Each intermediate fitting (e.g., short- and long-radius elbows, tees and reducers, welded attachments, and valves).

5. Containment Penetration Piping

a. Main Steam and Feedwater Piping

1) The main steam and feedwater system containment penetration piping including branch connections which are short in length and have no significant restraint to thermal expansion ~~and the preheat feedwater bypass tempering piping branch~~ meet the "break-exclusion" requirements of b. below. In addition, mechanistic breaks are postulated in other branches off the main steam and feedwater lines in accordance with ~~1., 2., 3., and 4.~~ Section 3.6.2.1.1.3 above. 40 Q110.08

2) The isolation valve cubicle housing the break-exclusion portion of main steam and feedwater piping and any safety-related components are designed for a nonmechanistic break occurring anywhere within the break-exclusion zone piping, except in piping and fittings which are associated with the bending and tortional restraints. 53

3) The nonmechanistic break is equivalent to one full cross sectional area of undefined type.

4) The penetration structure is capable of withstanding the pressure, temperature, and humidity and flooding transients from the nonmechanistic break.

6) When a break-exclusion zone is established, the terminal end for piping in the zone is consequently extended away from the containment anchor. The terminal end is located adjacent to the restraints that limit the bending and torsion moments exerted on the isolation valve as a consequence of pipe break. These piping restraints are:

   a) Located reasonably close to the isolation valves and located to optimize overall piping design.

   b) Located, as necessary, to prevent formation of a plastic hinge, following a piping failure, anywhere within the established break exclusion zone.

   c) Capable of withstanding the loadings resulting from a postulated pipe rupture beyond this portion of the piping such that neither valve operability nor the leaktight integrity of the containment is impaired.

7) Operability of the isolation valve must be assured for pipe break events where valve operation is required to ensure containment integrity or credit for valve operation is otherwise taken based on the valve integrity and function. 40

8) Branches originating from the piping run between isolation valves and the containment, ~~shall be~~ WHEN analyzed as part of the penetration piping, ~~and~~ are subject to the same rules as the main run if treated as part of the no-break region.

9) All piping in the break-exclusion zone must be either of seamless construction with full radiography of all circumferential welds, or of seamed construction with all longitudinal and circumferential welds fully radiographed.

10) All piping greater than one inch nominal size in the break exclusion zone shall be subject to an augmented inservice weld examination program.

11) The penetration structure housing a break-exclusion zone portion of high-energy piping and any safety-related components shall be designed for a nonmechanistic break identified in 5.a.3) and 4) above.

6 ~~7~~. A structure that separates a high-energy line outside containment from an essential component is designed to withstand the consequences of the pipe break in the high-energy line which produces the greatest effect at the structure irrespective of the fact that the criteria of Section 3.6.2.1.1 might not require such a break to be postulated.

3.6.2.1.2 <u>ASME Section III and Nonnuclear Piping - Moderate-Energy</u>: Through-wall leakage cracks are postulated in moderate-energy piping including branch runs larger than 1 in. nominal diameter as clarified below: 40 Q110.09

1. Through-wall leakage cracks are not required to be postulated in those portions of piping between containment isolation valves, provided they

erted on the isolation valve as a consequence of pipe break. These piping restraints are:

a) Located reasonably close to the isolation valves and located to optimize overall piping design.

b) Located, as necessary, to prevent formation of a plastic hinge, following a piping failure, anywhere within the established break exclusion zone. 40

c) Capable of withstanding the loadings resulting from a postulated pipe rupture beyond this portion of the piping

b. If the maximum stress range exceeds the limits specified in Sections 3.6.2.1.1.1.b.2 and 3.6.2.1.1.2.b but the axial stress is at least 1.5 times the circumferential stress range, only a circumferential break is postulated. 49

C. Longitudinal breaks however, are not postulated at ~~the following locations:~~ 40

~~a.~~ Terminal ends.

~~b. Intermediate points of Class 1 piping systems where the stress range as calculated by equations (10) and either (12) or (13) does not exceed 2.4 S_m as described in paragraph NB-3653 of the ASME B&PV~~

~~Code, Section III, and/or if the cumulative usage factor does not exceed 0.1~~.

~~e. Intermediate points of Class 2 and 3 piping systems where the maximum stress value, as calculated by the sum of equations (9) and (10) described in paragraph NC-3652 of the ASME B&PV Code, Section III, does not exceed 0.8 (1.2 S_h + S_A).~~

2. In piping whose nominal diameter is greater than 1 in. but less than 4 in., only circumferential breaks are postulated at each selected break location.

3. No breaks are postulated for piping whose nominal diameter is 1 in. or less.

3.6.2.1.3.3 Non-nuclear Piping - High-Energy - The types of breaks postulated for non-nuclear piping are the same as those discussed in Sections 3.6.2.1.3.2. The corresponding break locations are determined in accordance with Section 3.6.2.1.1.4.

3.6.2.1.4 Break/Crack Configuration:

3.6.2.1.4.1 High-Energy Break Configuration - Following a circumferential break, the two ends of the broken pipe are assumed to move clear of each other unless physically limited by piping restraints, structural members, or piping stiffness. 40 The effective cross-sectional (inside diameter) flow area of the pipe is used in the jet discharge evaluation. Movement is assumed to be in the direction of the jet reaction initially, with the total path controlled by the piping geometry.

The orientation of a longitudinal break, except when otherwise justified by a detailed stress analysis, is assumed to be oriented (but not concurrently) at two diametrically opposed points on the piping circumference. To maximize the out of plane bending the longitudinal break will be assumed to be perpendicular to the plane of the piping ~~a fitting for a nonaxisymmetric fitting and anywhere around the circumference of the fitting for axisymmetric fittings~~. The flow area of such a break is equal to the cross-sectional flow area of the pipe. Longitudinal and circumferential breaks are not postulated concurrently.

3.6.2.1.4.2 Moderate-Energy Crack Configuration - Moderate-energy crack openings are assumed to be a circular orifice with cross-sectional flow area equal to that of a rectangle one-half the pipe inside diameter in length and one-half pipe wall thickness in width.

3.6.2.2 Analytical Methods To Define Forcing Functions and Response Models.

3.6.2.2.1 Forcing Functions for Jet Thrust and Dynamic Model for Piping Response: The fluid conditions at the upstream source and at the break exit 49 dictate the analytical approach and approximations that are used to determine cracks. Note that for short periods of time, the pressure and enthalpy in certain systems will be higher than full or normal power operation i.e., 102 percent power. However, the full power mode establishes the maximum demands of safety systems in the event of a postulated pipe rupture. Other modes of normal operation have reduced needs for safety systems to bring the plant to a safe shutdown. Therefore, the full power operation mode is used to determine the thermodynamics state in the piping system for the calculation of fluid reaction forces. 40

3.6.2.3.2 <u>Dynamic Analysis Methods To Verify Integrity and Operability for the RCL</u>:

3.6.2.3.2.1 <u>General</u> - A LOCA is assumed to occur for a branch line break down to the second normally open automatic isolation valve (Case II, Figure 3.6.2-1) on outgoing lines and down to and including the second check valve 45 (Case III, Figure 3.6.2-1) on incoming lines normally with flow. A pipe break beyond the ~~restraint or~~ second check valve does not result in an uncontrolled loss of reactor coolant if either of the two valves in the line closes.

~~Accordingly, both of the automatic isolation valves are suitably protected and restrained as close to the valves as possible so that a pipe break beyond the restraint does not jeopardize the integrity and operability of the valves. Further,~~ periodic testing of the valves capability to perform their intended 40 function is essential. This criterion takes credit for only one of the two valves performing its intended function. For normally closed isolation or incoming check valves (Cases I and IV, Figure 3.6.2-1), a LOCA is assumed to occur for pipe breaks on the reactor side of the valve.

Branch lines connected to the RCL are defined as large strictly for the purpose of pipe break criteria when they have an inside diameter greater than 4 45 in. up to the largest connecting line. Rupture of these lines results in a rapid blowdown from the RCL, and protection is basically provided by the accumulators and the low-head safety injection (LHSI) pumps.

40

Branch lines connected to the RCL are defined as small for the purpose of pipe break analysis if they have an inside diameter equal to or less than 4 in. This size is such that Emergency Core Cooling System (ECCS) analyses, using realistic assumptions, show that no fuel cladding damage is expected for a 45 break area of up to 12.5 in.^{2} corresponding to 4 in. inside diameter piping.

Engineered safety features (ESFs) are provided for core cooling and boration, pressure reduction, and activity confinement in the event of a LOCA or steam 40 or feedwater line break accident to ensure that the public is protected in accordance with 10CFR100 Guidelines. These safety systems are designed to provide protection for an RCS pipe rupture of a size up to and including a double-ended severence of the RCS main loop. 45

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To assure the continued integrity of the essential components and the engineered safety systems, consideration is given to the consequential effects of the pipe break itself to the extent that:

1. The minimum performance capabilities of the engineered safety systems are not reduced below that required to protect against the postulated break.

2. The containment leaktightness is not decreased below the design value if the break leads to a LOCA (1).

3. Propagation of damage is limited in type and/or degree to the extent that:

    a. A pipe break which is not a LOCA or steam/feedwater line break will not cause a LOCA or steam/feedwater line break.

    b. An RCS pipe break will not cause a steam or feedwater system pipe break, and vice versa, in excess of small ~~instrument or sample~~ lines which are not required to function following accidents.

INSERT 1 →

3.6.2.3.2.2 Large RCS Piping - Propagation of damage resulting from the rupture of an RCL is permitted to occur but must not exceed the design basis for calculating containment and subcompartment pressures, loop hydraulic forces, reactor internals, reaction loads, primary equipment support loads, or emergency core cooling system performance. 40

Large branch line piping, as defined in Section 3.6.2.3.2.1, is restrained to meet the following criteria in addition to items 1 thru 3 of Section 3.6.2.3.2.1 for a pipe break resulting in a LOCA:

1. Propagation of the break to the unaffected loops is [limited to small instrument or sample lines] ~~prevented~~ to ensure the delivery capacity of the accumulators and low head pumps.

2. Propagation of the break in the affected loop is permitted to occur but does not exceed 20 percent of the flow area of the line which initially ruptured. The criterion is voluntarily applied so as not to substantially increase the severity of the LOCA.

INSERT 2 →

3.6.2.3.2.3 Small [RCL] Branch Lines - Should one of the small pressurized [RCL branch] lines, as defined in Section 3.6.2.3.2.1, fail and result in a LOCA, the piping is restrained or arranged to meet the following criteria in addition to items 1 through 3 of Section 3.6.2.3.2.1:

1. Break propagation is limited to [small instrument or sample lines in] the [un]affected leg [and loops]; i.e., propagation to the other leg of the affected loop and to the other loops is ~~prevented~~ [minimized]. Damage to the high-head safety injection (HHSI) lines connected to the other leg of the affected loop or to the other loops is prevented.

---

(1) The containment is here defined as the containment structure liner and penetrations and the steam generator shell, the steam generator steam side instrumentation connections, the steam, feedwater, blowdown, and steam generator drain pipes within the containment structure.

INSERT

Page 3.6-19

INSERT 1 & 2

Exceptions to these criteria may be made if specific evaluations show no adverse effects occur to accident mitigation and recovery systems.

2. Propagation of the break in the affected leg is permitted but must be limited to a total break area of 12.5 in.^{2}. ~~The exception to this case is when the initiating small break is a cold leg HHSI line. Further propagation is not permitted for this case.~~

3. Propagation of the break to a HHSI line connected to the affected leg is prevented if the line break results in a loss of core cooling capability due to a spilling injection line. 40

INSERT →

3.6.2.3.2.4 <u>Design and Verification of Adequacy of RCL Components and Supports</u> - The methods described below are used in the Westinghouse design and verification of the adequacy of primary RCL components and supports. These methods are used only to determine jet impingement loads on RCL components and supports and are not used for design and checking of walls, RCS barriers, cable trays, etc. 45

The design basis postulated pipe rupture locations for the RCL piping are determined using the criteria given in Section 3.6.2.1. These design basis ruptures are used as the rupture locations for consideration of jet impingement effects on primary equipment and supports.

A dynamic analysis is used to determine maximum piping displacements at each design basis rupture location. The maximum piping displacements are used to compute the effective rupture flow area at each location. The flow area and rupture orientation is then used to determine the jet flow pattern and to identify any primary components which are potential targets for jet impingement. 40

The jet thrust at the point of rupture is based on the fluid pressure and temperature conditions occurring during full (100 percent) power operating conditions of the plant. At the point of rupture, the jet force is equal and opposite to the jet thrust. The force of the jet is conservatively assumed to be constant throughout the jet flow distance. The sub-cooled jet is assumed to expand uniformly at a half-angle of 10 degrees, from which the area of the jet at the target and the fraction of the jet intercepted by the target structure can be readily determined.

The shape of the target affects the amount of momentum change in the jet and thus affects the impingement force on the target. The target shape factor is used to account for target shapes which do not deflect the flow 90 degrees away from the jet axis. 45

The method used to compute the jet impingement load on a target is one of the following:

1. The dynamic effect of jet impingement on the target structure is evaluated by applying a step load whose magnitude is given by:

$$F_j = K_o P_o A_{mB} RS$$

where:

F_j = Jet impingement load on target

INSERT

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Exceptions to these criteria may be made if specific evaluations show no adverse effects occur to accident mitigation and recovery systems.

The restraint structure is typically a structural steel frame or truss and the energy-absorbing element is usually either stainless steel U-bars or energy-absorbing material as described below:

1. Stainless Steel U-Bar

This type consists of one or more U-shaped, upset-threaded rods of stainless steel looped around the pipe but not in contact with the pipe to allow unimpeded pipe motion during seismic and thermal movement of the pipe. At rupture, the pipe moves against the U-bars, which absorb the kinetic energy of the pipe motion by yielding plastically. A typical example of a U-bar restraint is shown in Figure 3.6.2-3.

2. Energy Absorbing Material 40

This type of restraint consists of a crushable, stainless steel, internally honeycomb-shaped element designed to yield plastically under impact of the whipping pipe. A design hot position gap is provided between the pipe and the energy-absorbing material to allow unimpeded pipe motion during seismic and thermal pipe movements. A typical example of an energy-absorbing material restraint is shown in Figure 3.6.2-4.

3. 5-Way Restraint

A five-way restraint is utilized to protect the main steam isolation valves (MSIVs) and main feedwater isolation valves in the event of a postulated pipe rupture outside the Containment. This restraint is designed so that postulated pipe breaks beyond the five-way restraint will not result in stresses greater than 1.8 S_h being transmitted to the piping between the isolation valve and containment penetration or formation of a plastic hinge between the isolation valve and the restraint.

~~4. Containment Main Steam Line Restraints~~ 53

~~The main steam line restraints inside containment are designed using nonlinear, inelastic methods with allowable ductilities given in Table 3.5-13. The anchorages to the internal structure are designed to the restraint backup structure using standard elastic design methods to ensure sufficient anchorage.~~

3.6.2.3.3.2 Restraints for RCL - Pipe restraint types and locations are discussed in Section 5.4.14. Loading combinations and stress limits are discussed in Section 3.9.1. 45

3.6.2.3.4 Analytical Methods:

3.6.2.3.4.1 Pipe Whip Restraints Other than RCL Restraints - 40 Q11

1. Location of Restraints 11

a. For purposes of determining pipe hinge length and thus locating the pipe whip restraints, the plastic moment of the pipe ~~is~~ maybe determined in the following manner:

$$M_p = 1.1 z_p S_y$$

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...ere:

z_p - Plastic section modulus of pipe $= \frac{4}{3}(r_o^3 - r_i^3)$

INSERT 1 → ~~D_m - Mean piping diameter~~

t - Wall thickness

S_y - Yield stress at pipe operating temperature.

1.1 - 10-percent factor to account for strain hardening (for T < 400°F)

INSERT 2 →

Pipe whip restraints are located as close to the axis of the reaction thrust force break as practicable. Pipe whip restraints are generally located so that a plastic hinge does not form in the pipe. If, due to physical limitations, pipe whip restraints are located so that a plastic hinge can form, the consequences of the whipping pipe and the jet impingement effect are further investigated. Lateral guides are provided where necessary to predict and control pipe motion.

b. Generally, restraints are designed and located with sufficient clearances between the pipe and the restraint such that they do not interact and cause additional piping stresses. A design hot position gap is provided that will allow maximum predicted thermal, seismic, and seismic anchor movement displacements to occur without interaction. 40 Q110.11

Exception to this general criterion may occur when a pipe support and restraint are incorporated into the same structural steel frame, or when a zero design gap is required. In these cases the restraint is included in the piping analysis.

c. In general, the restraints do not prevent the access required to conduct inservice inspection examination of piping welds. When the location of the restraint makes the piping welds inaccessible for inservice inspection, a portion of the restraint is made removable to provide accessibility.

2. Analysis and Design

Analysis and design of pipe whip restraints for postulated pipe break effects are in accordance with Ref. 3.6-5. Specifically, the following criteria are adopted in analysis and design:

a. Pipe whip restraints are designed based on energy absorption principles by considering the elastic-plastic, strain-hardening behavior of the materials used.

b. A rebound factor of 1.1 is applied to the jet thrust force (when static analyses are performed).

INSERT PAGE 3.6-22

Insert 1

r_i = inside radius of pipe

r_o = outside radius of pipe

Insert 2

Alternatively the load carrying capacity of the pipe may be determined by a suitable analytic model per Reference 3.6-9.

c. Except in cases where calculations are performed to verify that a plastic hinge is formed, the energy absorbed by the ruptured pipe is conservatively assumed to be zero; i.e., the thrust force developed goes directly into moving the broken pipe and is not reduced by the force required to bend the pipe. 40 Q110.11

d. In elastic-plastic design, limits for strains are as follows:

ϵ = Allowable strain used in design.

No Change

REFERENCES

Section 3.6:

3.6-1 "Pipe Breaks for the LOCA Analysis of the Westinghouse Primary Coolant Loop," WCAP-8082-P-A, (proprietary) and WCAP-8172-A (nonproprietary), January 1975.

3.6-2 "Subcompartment Pressure Analyses," BN-TOP-4, Rev. 1, Bechtel Power Corporation, October 1977.

3.6-3 USNRC BTP MEB 3-1 Postulated Break and Leakage Locations in Fluid System Piping Outside Containment. Branch Technical Position attached to SRP 3.6.2, November 24, 1975.

3.6-4 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, 1974 and 1975 Winter Addenda and other Addenda as appropriate.

3.6-5 "Design for Pipe Break Effects," Bechtel Power Corporation, BN-TOP-2, Revision 2, May 1974.

3.6-6 Moody, F. J., "Fluid Reaction and Impingement Loads." Paper presented at the ASCE Specialty Conference, Chicago, December 1973.

3.6-7 "MULTIFLEX, A FORTRAN-IV Computer Program for Analyzing Thermal-Hydraulic-Structure System Dynamics," WCAP-8708 (proprietary), February 1976, and WCAP-8709 (nonproprietary), February 1976.

3.6-8 "Documentation of Selected Westinghouse Structural Analysis Computer Codes," WCAP-8252, Revision 1, May 1977.

3.6-9 ANSI/ANS - 58.2, "American National Standard Design Basis for Protection of Nuclear Power Plants Against Effects of Postulated Pipe Rupture," December, 1980. 40

3.6-10 Bordelon, F.M., "A Comprehensive Space-Time Dependent Analysis of Loss of Coolant (SATAN IV Digital Code)" WCAP-7263, Proprietary (August 1971) and WCAP-7750, Non-Proprietary (August 1971) 45

3.6-11 "PIPERUP" - Pipe Rupture Analysis Program, ME351, June 24, 1982

3.6-12 Biggs, J.M., Introduction to Structural Dynamics, McGraw-Hill Book Company, New York, 1964 49

INSERT 1 & 2

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INSERT 1

3.6-13 NUREG/CR 2913, "Two Phase Jet Loads", dated January, 1983

INSERT 2

3.6-14 "Technical Bases for Eliminating Large Primary Loop Pipe Ruptures as the Structural Design Basis for the South Texas Project", WCAP-10559, Proprietary (May 1984) and WCAP-10560, Non-Proprietary (May 1984)

TABLE 3.6.1-2

DESIGN COMPARISON TO POSITIONS OF NRC BRANCH TECHNICAL POSITIONS ASB 3-1

Branch Technical Position ASB 3-1	STP Design
B.1 Plant Arrangement Protection of essential 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.	B.1 Conforms. See Section 3.6.1.3 B.1.a Conforms. See Section 3.6.1.3.2.(1) B.1.a(1) Partial conformance as follows: - The essential equipment located in the main steam and main feedwater penetration areas is designed to be protected from or qualified the environmental effects (compartment pressure, temperature, humidity, and flooding) resulting from a full circumferential break (single area) in the main steam or main feedwater lines. - The essential equipment is designed to be protected from the jet impingement and pipe whip effects resulting from a full circumferential break postulated in ~~the largest~~ branch lines associated with the main steam or main feedwater lines. B.1.a.(2) Conforms. See Section 3.6.1.2.

40

TABLE 3.6.1-2 (Continued)

DESIGN COMPARISON TO POSITIONS OF NRC BRANCH TECHNICAL POSITIONS ASB 3-1

Branch Technical Position ASB 3-1	STP Design
	B.1.b Conforms. See Section 3.6.1.3.2.(2)
	B.1.c Conforms. See Sections 3.6.1.3.2.(2); 3.6.1.3.2.(3); 3.6.1.3.3; and 3.6.2.3.
	B.1.c.1(a) Conforms. As part of the design process, the restraint gap is verified large enough to accommodate thermal, seismic, and seismic anchor movements and other occasional loads.
	B.1.c.1(b) Partial conformance. See Section 3.6.2.3.3.1. Additionally, final pipe whip restraint gap will be verified during hot-functional testing and thus will account for any differential settlement. Pipe relaxation is not specifically considered in the STP design.
	B.1.c.1(c) See response to items (a) and (b) above.
	B.1.c.(2) PARTIAL Conform~~s~~ANCE. Restraints which do not have adequate inservice inspection pipe weld space requirements are made removable or EXCEPTIONS ARE DOCUMENTED IN THE ISI PROGRAM. SEE SECTION 3.6.2.1.1.1(5).
B.2 Design Features	
B.2.a Essential systems and components should be designed to meet the seismic design requirements of Regulatory Guide 1.29.	B.2.a Conforms, as described in Sections 1.9 and 3.2.

TABLE 3.6.1-3

DESIGN COMPARISON TO NRC BRANCH TECHNICAL POSITIONS MEB 3-1 (1)

Branch Technical Position MEB 3-1	STP Design
B.1 High-Energy Fluid System Piping	
B.1.a Fluid systems separated from essential systems and components.	B.1.a. Conforms. See Section 3.6.1.3.2.1.
B.1.b Fluid system piping in containment penetration areas.	B.1.b. PARTIAL Conformance. See Section 3.6.2.1.1.5.
B.1.b.(1)(a)-(c)	There is no Class 1 piping in containment penetration areas in the STP.
B.1.b.(1)(d)	Conforms. See Section 3.6.2.1.1.5. 40
B.1.b.(1)(e)	Conforms. For further discussion see Section 3.6.2.1.1.5.
B.1.b.(2)	Conforms. See Section 3.6.2.1.1.5.
B.1.b.(3)	Conforms. See Section 3.6.2.1.1.5.
B.1.b.(4)	See conformance statement to ASB 3-1 position B.2.c.(1) and Section 3.6.2.1.1.5.b.(4).2.d.

~~1. This table summarizes conformances as to ASB 3-1 and MEB 3-1 which also covers the implementation of WCAP-8082-P-A and WCAP-8172-A.~~

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TABLE 3.6.1-3 (Continued)

DESIGN COMPARISON TO NRC BRANCH TECHNICAL POSITIONS MEB 3-1 (1)

Branch Technical Position MEB 3-1	STP Design	
B.1.b.(5)	High-energy containment flued head penetrations are integrally forged piped fittings. Pipe whip restraints do not require welding directly to the outer surface of the piping, except where such welds are 100-percent volumetrically examined in service and a review for local stresses is performed.	40
B.1.b.(6)	No guard pipes in high energy lines.	
B.1.b.(7)	Conforms. See Sections 3.6.2.1.1.5.b.5 and 10.	
B.1.c Postulation of pipe rupture in areas other than containment penetration.	B.1.c. Conforms. See Section 3.6.2.1.1.	
	B.1.c.(1)(a)-(d) Partial Conformance. Break locations are limited to the stress determined breaks and terminal end breaks. See Section 3.6.2.1.1.1.	45
	B.1.c.(2) Partial Conformance. Break locations are limited to the stress determined breaks and terminal end breaks. See Section 3.6.2.1.1.2.	
	B.1.c.(3) Conforms. See Section 3.6.2.1.1.4.	
	B.1.c.(4) Partial Conformance. Conformance to structures separating a high energy line from an essential component is limited to high energy lines outside containment. However, structures inside containment are designed for the dynamic effects of postalulated mechanistic breaks. See Sections 3.6.2.1.1.2 and 3.6.2.1.1.7.	50 Q210 .26N

~~1. This table summarizes conformances as to ASB 3-1 and MEB 3-1 which also covers the implementation of WCAP-8082-P-A and WCAP-8172-A.~~ 26

TABLE 3.6.1-3 (Continued)

DESIGN COMPARISON TO NRC BRANCH TECHNICAL POSITIONS MEB 3-1

Branch Technical Position MEB 3-1	STP Design
B.1.c (Continued)	B.1.d. Conforms. See Section 3.6.2.5. 40
	B.1.e. Partial Conformance. In lieu of postulating high energy leakage cracks for environmental effects, certain non-mechanistic full circumferential breaks are postulated to establish the environmental conditions inside containment. The bulk containment effects due to leakage cracks are enveloped by these breaks. 50 Q210.35N
B.2 Moderate-Energy Fluid System Piping	B.2.a. Conforms. See Section 3.6.1.3 and appendix (later).
	B.2.b. Conforms. See Section 3.6.2.1.2.
	B.2.c.(1)-(2) Conforms. See Section 3.6.2.1.2.
	B.2.d. Conforms. See Section 3.6.2.1.2. 40
	B.2.e. Conforms. See Section 3.6.1.1.1.
B.3 Type of Breaks and Leakage Cracks in Fluid System Piping	B.3.a.(1) Conforms. See Section 3.6.2.1.3.
	B.3.a.(2) Conforms. See Section 3.6.2.1.3.
	B.3.a.(3) Conforms. See Section 3.6.2.1.4.1.
	B.3.a.(4) See Section 3.6.2.2.1.
	B.3.a.(5) Conforms. See Section 3.6.1.1.10.
	B.3.b. Conforms. See Section 3.6.2.1.3.
	B.3.c. Conforms. See Section 3.6.2.1, 3.6.1.3.3.6b, and 3.6.1.2. 45

~~1. This table summarizes conformances as to ASB 3-1 and MEB 3-1 which also covers the implementation of WCAP-8082-P-A and WCAP-8172-A.~~ 40

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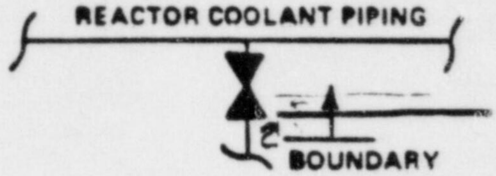
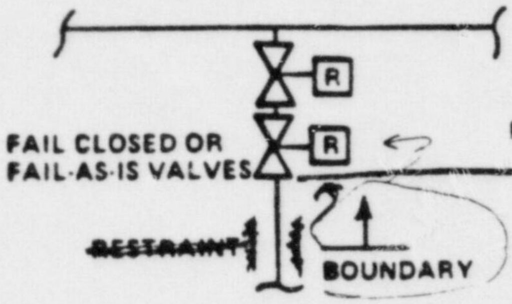
CASE I OUTGOING LINES WITH NORMALLY CLOSED VALVE

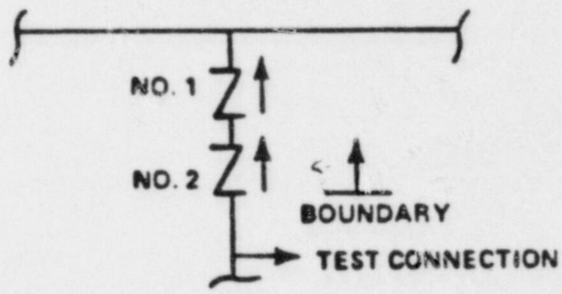


CASE II OUTGOING LINES WITH NORMALLY OPEN VALVES

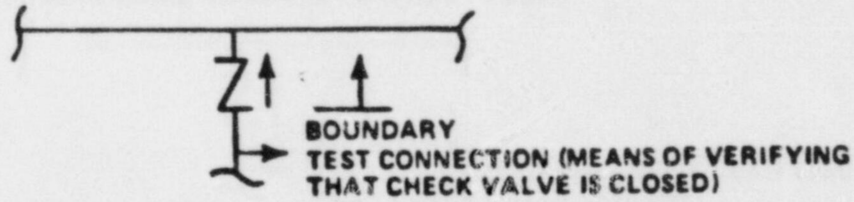


NOTE: THE REACTOR COOLANT PUMP NO. 1 SEAL IS ASSUMED TO BE EQUIVALENT TO FIRST VALVE

CASE III INCOMING LINES NORMALLY WITH FLOW



CASE IV INCOMING LINES NORMALLY WITHOUT FLOW



CASE V ALL INSTRUMENTATION TUBING AND INSTRUMENTS CONNECTED DIRECTLY TO THE REACTOR COOLANT SYSTEM IS CONSIDERED AS A BOUNDARY. HOWEVER, A BREAK WITHIN THIS BOUNDARY RESULTS IN A RELATIVELY SMALL FLOW WHICH CAN NORMALLY BE MADE UP WITH THE CHARGING SYSTEM.

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LOSS OF REACTOR COOLANT ACCIDENT BOUNDARY LIMITS

Figure 3.6.2-1 Amendment 40

References

Appendix 3.6.A:

3.6.A.4.1 Reif, F.J. Fundamentals of Statistical and Thermal Physics, McGraw-Hill Book Co., p. 183.

3.6.A.4.2 Kennan, J.H. et al, Steam Tables, John Wiley & Sons, Inc., New York, 1969. 53

3.6.A.4.3 Keepan, J.H., and J. Kaye, Gas Tables, John Wiley & Sons, Inc., New York, 1948.

3.6.A.4.4 Bechtel Topical Report BN-TOP-4 Rev. 1, October 1977, "Subcompartment Pressure and Temperature Transient Analysis". This report was approved by the NRC in February, 1979.

3.6.A.4.5 ~~LOFTRAN, "later~~" Burnett, T.W.T., et.al., "LOFTRAN Code Description," WCAP-7907-P-A (Proprietary Class 2), WCAP-7907-A (Proprietary Class 3), April 1984.

The tank is also equipped with an internal spray and a drain which function to cool the water following a discharge. Cold water is drawn from the reactor makeup water system, or the contents of the tank are circulated through the reactor coolant drain tank heat exchanger of the LWPS and back into the spray header. 38

The nitrogen gas blanket is used to control the atmosphere in the tank and to allow room for the expansion of the original water plus the condensed steam discharge. The tank gas volume is calculated using a final tank pressure of 50 psig based on design conditions. Consequently the design discharge for the worst case initial conditions will raise internal tank pressure to a maximum of 50 psig, a pressure low enough to prevent fatigue of the rupture disks. Provision is made to permit the gas in the tank to be periodically analyzed to monitor the concentration of hydrogen and/or oxygen.

The contents of the vessel can be drained to the waste holdup tank in the LWPS or the recycle holdup tank in the Boron Recycle System (BRS) via the reactor coolant drain tank pumps in the LWPS. 38

38

5.4.11.3 Safety Evaluation. The pressurizer relief discharge system does not constitute part of the RCPB per 10CFR50, Section 50.2, since all of its components are downstream of the RCS safety and relief valves. Thus, General Design Criteria 14 and 15 are not applicable. Furthermore, failure of the pressurizer relief system will not impair the capability for safe plant shutdown.

NO RESTRAINTS ARE NECESSARY ON

~~The design of the system piping layout and piping restraints is consistent with RG 1.46.~~ The safety and relief valve discharge piping ~~is restrained~~ to ensure the integrity and operability of the valves. ~~are maintained in the event of a rupture~~. RG 1.67 is not applicable since the system is not an open discharge system.

The pressurizer relief discharge system is capable of handling the design discharge of steam without exceeding the design pressure and temperature. The volume of nitrogen in the pressurizer relief tank is that which is required to limit the maximum tank pressure to 50 psig from a design basis discharge. The volume of water in the pressurizer relief tank is capable of absorbing the heat from the assumed discharge maintaining the water temperature below 200°F. If a discharge exceeding the design basis should occur, the rupture discs on the tank ensure overpressure protection by providing means for passing the discharge through the tank to the Containment.

The rupture discs on the relief tank have a relief capacity equal to or greater than the combined capacity of the pressurizer safety valves. The tank design pressure is twice the calculated pressure resulting from the design basis safety valve discharge described in Section 5.4.11.1. The tank and rupture disc holders are also designed for full vacuum to prevent tank collapse if the contents cool following a discharge without nitrogen being added.

The discharge piping from the safety and relief valves to the relief tank is sufficiently large to prevent backpressure at the safety valves from exceeding 20 percent of the setpoint pressure at full flow.