NORTHERN STATES POWER - Prairie Island

Amendment 31

INSTRUCTION SHEET FOR INSERTION

Amendment No. 31 is enclosed for insertion into the Prairie Island FSAR.

The following listing of material furnished as Amendment No. 31 will serve as a check list for entering revised and new pages. Enter the revised or new pages listed in Column 1 below, discarding only the revised or new pages listed in Column 2. Pages with no revision date are exact replicas of the originals.

| Column 1 | | Column 2 |
|---|---|---|
| (Insert) | | (Remove) |
| I-3/4(28/31)* | | I-3/4(28) |
| I-5/6(28/31) | | I-5/6(28) |
| I-6a/6b(31/31) | | |
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| I-8c/blank(31/-) | | |
| I-9/10(31/28 | | I-9/10(28) |
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| I-27/28(31/31) | | I-27/28(28) |
| I-29/blank(31/-) | | I-29/blank(28) |
| Table 1.3-1(1 of 2)/(2 of 2) (31/31) | | Table I.3-1(1 of 2)/(2 of 2) (29) |
| Table 1.4-1(1 of 2)/(2 of 2) (31/31) | | Table I.4-1(1 of 2)/(2 of 2) (29) |
| Table 1.5-1 (1 of 2)/(2 of 2) (31/31) | | |
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| Figure 1.3-1 | (31) | Figure 1.3-1(29) |
| Figure 1.3-2 | (31) | |
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| Figure 1.5-1 | (31) | |
| Figure 1.6-1 | (31) | |

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Column 1 & Column 2 (Continued)

**Column 1**
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Figure 1.7-1 (31)
Figure 1.9-1 (31)
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9/10 (31/31)
10a/blank (31/-)
11/12 (31/31)
13/14 (31/31)
Table I.A-1 ( 1 of 2)/(2 of 2) (31/31)
Table I.A-1/blank (31/-)
Figure I.A-1 (31)
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Figure I.A-3 (31)
Figure I.A-4 (31)
Figure I.A-4.1 (31)
Figure I.A-19 (31)
Figure I.A-20 (31)
Figure I.A-21 thru 97 (31)

**Column 2**
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1/2 (29)
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Table I.A-1/I.A-2(29)
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Figure I.A-1 (29)
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Figure I.A-19 (29)
Figure I.A-20 (29)
Figure I.A-21 thru 26 (29)

Column 1 & Column 2 (Continued)

| Column 1 (Insert) | | Column 2 (Remove) |
|---|---|---|
| Figure 1.7-1 | (31) | |
| Figure 1.9-1 | (31) | |
| 1/2 | (31/31 | 1/2 (29) |
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| 11/12 | (31/31) | 11/12 (29) |
| 13/14 | (31/31) | 13/14 (29) |
| Table I.A-1 ( 1 of 2)/(2 of 2) | (31/31) | Table I.A-1/I.A-2(29) |
| Table I.A-1/blank | (31/-) | Table I.A-3/I.A-4 (29) |
| Figure I.A-1 | (31) | Figure I.A-1 (29) |
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| Figure I.A-3 | (31) | Figure I.A-3 (29) |
| Figure I.A-4 | (31) | Figure I.A-4 (29) |
| Figure I.A-4.1 | (31) | |
| Figure I.A-19 | (31) | Figure I.A-19 (29) |
| Figure I.A-20 | (31) | Figure I.A-20 (29) |
| Figure I.A-21 thru 97 | (31) | Figure I.A-21 thru 26 (29) |

exceed 0.8 $(S_h + S_A)$* or the expansion stresses exceed 0.8 $S_A$ or

b) a high-stress point has been calculated (minimum of 2 points)

## Size and Orientation

Once a design basis break location has been established, as defined above, the break orientation and size depend upon the following additional conditions:

Longitudinal breaks in piping runs or branch runs will be examined for pipes of 4" nominal diameter and larger. A longitudinal break is parallel to the pipe axis and oriented at any point around the pipe circumference. The break area is equal to the effective cross-sectional flow area upstream of the break location with the length of the break equivalent to twice the inside pipe diameter. Dynamic forces resulting from such breaks are assumed to cause lateral pipe movements in the direction normal to the pipe axis.

Circumferential breaks must be considered in piping runs and branch runs exceeding a nominal 1-inch diameter. A circumferential break is perpendicular to the pipe axis, and the break area is equivalent to the cross-sectional area of the ruptured pipe. Dynamic forces resulting from such breaks are assumed to separate the piping axially and cause whipping in any direction normal to the pipe axis.

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*$S_h$ is the stress calculated by the rules of NC-3600 and ND-3600 for Class 2 and 3 components, respectively, of the ASME Code Section III Winter 1972 Addenda.

$S_A$ is the allowable stress range for expansion stress calculated by the rules of NC-3600 of the ASME Code, Section III, or the USA Standard Code for Pressure Piping, ANSI B31.1.0-1967.

Design Basis Crack

A design basis crack is defined as a single open crack of a size of one-half the pipe diameter in length and one-half the pipe wall thickness in width. The location of this break can be anywhere along the length of the pipe.

Location

Where high-energy pipes are routed in the vicinity of structures and systems necessary for safe shutdown of the nuclear plant, a postulated crack in the
31 pipe system has been postulated. The criteria for evaluating the effects of jet impingement and resulting steam-air environment are discussed in subsequent paragraphs.

Size and Orientation

The orientation of the postulated crack can be in any direction in terms of affected required equipment. The most adverse locations with respect to the
31 affected equipment were selected.

## I.2.2 CRITERIA FOR PIPE RUPTURE INDUCED LOADS

Pipe Whip

The reaction load resulting from pipe rupture has the duration and initial conditions to adequately represent the jet stream dynamics and the system
31 pressure characteristics.

The forcing functions used in the dynamic analysis are described in Section I.9.



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The location of breaks for pipe-whip considerations are those defined in Section I.2.1. The loads induced from pipe rupture will include the effects of any line restrictions, for example, flow limiters, between the pressure source and the break location.

The effect of break-opening geometry on the magnitude of reaction loads will be incorporated in the analysis by the application of an appropriate, but conservative, discharge coefficient. For all circumferential breaks, the discharge coefficient will have a value of 1.0. For longitudinal breaks, the discharge coefficient will be determined by the postulated break-opening geometry for each case and may have a value less than but not greater than 0.85.

If a whipping pipe impacts adjacent pipes of equal or greater nominal pipe size and equal or heavier wall thickness, the adjacent pipe will be considered to be free from rupture. Protection from pipe-whip will not be provided if pipe rupture occurs in such a manner that the unrestrained pipe movement of either end of the ruptured pipe, in any possible direction about a plastic hinge formed at the nearest pipe-whip restraint, cannot impact any structure, system or component required for that incident.

Piping that is physically separated or isolated from structures, systems or components important to safety will be excluded from the analysis. The physical separation or isolation may take the form of protective barriers or pipe restraints designed specifically for pipe-whip, such as concrete encasement.

Compartment Pressure-Loading and Stress

Compartment differential pressure loadings from design basis events have been considered. The mass and energy flow rates, from either a single-ended or double-ended break, were computed on the basis of the flow characteristics of the pipe immediately adjacent to the break and were chosen to give a conservative calculation of compartment pressures. The steam quality was based upon the steam generator blowdown characteristics.

The working stress design was chosen over other A.C.I. - approved methods of analysis to maintain consistency with Appendix B. At the levels of stress permitted at pipe failure - $F_c$" $0.85f'_c$ and $f_s = 0.90$Y.S.- The actual stress distribution is non-linear but it is not necessary to utilize an analytical method that bases its concrete compressive resistance on a non-linear stress distribution of the concrete. For ultimate strength design, the A.C.I. code's 1963 and 1971 editions favor Whitney's rectangular concrete stress distribution over Stucci's non-linear stress distribution.

A comparison of W.S.D. with Load Factors and Whitney' stress block for ultimate strength design proved favorable, thus indicating the adequacy of W.S.D. for use in evaluation of concrete elements at pipe failure.

The Class I seismic design loadings are up to 0.5 $F_y$. The present accident calculations increases the loading from $0.5F_y$ to 0.9 $F_y$.

Jet Impingement

Jet impingement loads safety-related equipment, components, and structures have been considered for the design basis cases defined in Section 1.2.1 in a high-energy system. The magnitude and area of influence of the jet was determined for each break according to the break location, size, and orientation criteria given in Section 1.2.1 and the procedures described in Section 1.5. The jet forces or loads at the point of rupture will be consistent with those used in the pipe whip analysis, and were based on the most severe fluid pressure and temperature conditions occuring during normal or upset plant operating modes. Jet-loadings were not considered to vary with time, but were conservatively based on the initial conditions at the time of rupture.

Concrete Shear (Punching) Stress

The stresses allowed on concrete elements at time of pipe rupture include $f_c = 0.85\ F'_c$ and $f_s = 0.90Y.S.$ For concrete compression and steel tension respectively. The allowable stresses for shear, bond, etc. were determined from the load factors associated with the compressive and tensile allowables. The load factors are developed as follows : The steel stress code allowable is $0.5f_y$ for A615-40 thus $.9/.5 = 1.8$ and the concrete stress code allowable is $0.45f'c$ thus $.85/.45 = 1.89$. Using 1.8 as the load factor for both concrete and steel maintains ductility within the concrete element, since steel is the governing material. The concrete stress is limited to $fc = 1.8\ x.45f'c = 0.81f\ \ 0.85f'c$.

The jet geometry, where it impacts a concrete wall, is normally ellipsoidal; the ellipsoid perimeter defines the (punching) shear area. (See Section I.11).

The allowable stress for (punching) shear is therefore 1.8 times the provisions of A.C.I. 318-63 Section 1207.

The dynamic forces associated with the jets were evaluated with respect to their distance and spread from the pipe separation or crack. The magnitudes of the jet force and area of loading and the punching shear capacity were compared and the shear capacity was sufficient to eliminate the need for guard pipes. Where shear was found adequate, the concrete element was checked for other possible modes of overstress or failure.

Jet Erosion of Concrete

The erosion of concrete by steam jets was evaluated in WCAP-7391, "pressurized water and steam jet effects on concrete" by Westinghouse Atomic Power Division. To summarize the tests, five reinforced concrete beams were subjected to steam jets with nozzle diameters of 1, 2 and 4 inches. The distances investigated between nozzles and beams were 1 foot and 4 feet and the initial system pressure was 2250 psi. The results are as follows:
(Section 4, "Evaluation of Beam Behavior", pg 4-2):

"4.2 EROSION EFFECTS

The erosion under all beam tests was observed to be (at most) 30 mils of surface paste removal, with no significant loss of either fine or coarse aggregate. The resultant surfaces showed the same appearance as would be present after light sandblasting. It can thus be concluded that short-term erosion of concrete surfaces as a result of either a loss-of-coolant accident or steam line break is definitely not a design consideration."

From Section 5, "Conclusions and Design Recommendations," pg 5-1:

"5.1 EROSION

As a result of the test program, no evidence was seen that concrete erosion should be a concrete design consideration. On this basis, it is recommended that no consideration be given to erosion effects in the design of concrete structures to withstand the blowdown loads for pressure and temperature conditions used in this study."

## I.2.3 DESIGN CRITERIA TO MITIGATE CONSEQUENCES OF PIPE RUPTURE

Pipe Restraints

The piping restraints will be designed to accommodate the loading induced by the reaction or whipping forces from design basis breaks. For a specific break location the pipe restraint will accommodate a longitudinal break
31 extending one pipe diameter on each side of the high-stress point or a circumferential break at the high-stress point.

Structural Components

**Existing seismic Class I structures will be reviewed for their adequacy. If required, these structures will be modified to the extent necessary to guarantee their integrity. Any new seismic Class I structures will be designed to withstand the effects of a postulated high energy system pipe failure. The analysis will consider the effects of pressure**
31 **and temperature transients** and the static, thermal, and dynamic reactions of **the pipe in conjunction with the applicable loads as listed in Appendix B.**

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

Failure of any structure, including seismic Class II or Class III structures, caused by the postulated accident will be reviewed to assure that it will not cause failure of any other structure, system, or component in a manner to preclude the mitigation of the consequences of the accident and the capability to bring the plant to a cold shutdown condition.

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Criteria to analyze the structural adequacy of the existing or modified seismic Class I structure and the design of new seismic Class I structures where required will be in accordance with Appendix B.6. The method of evaluating stresses will be in accordance with the working-stress method.

<u>Design Basis for Guard Pipes</u>

Two basic types of guard pipes will be used:

1. Encapsulation sleeve for the purpose of limiting the flow of steam or water from a pipe break.

2. Impingement barrier for the control of the direction of a jet generated from a pipe break.

<u>Encapsulation Sleeve</u>

The following requirements shall be met for the application of encapsulation sleeves at design basis break locations as means of reducing compartment pressurization levels in the event of a pipe severance:

1. The encapsulation sleeve shall be designed and supported in a manner which will not introduce significant strain concentrations on the encapsulated section of piping.

2. The piping beyond the encapsulation sleeve shall be provided with pipe whip restraints (or anchors) which restrict its axial displacement and motion within the sleeve following a postulated circumferential pipe break.

3. The encapsulation sleeve shall be designed (a) to withstand the dynamic forces of internal pressurization resulting from the escape of high energy fluid at the postulated pipe break location assuming complete pipe severance and axial separation to the extent permitted by the pipe restraints, and (b) to restrict the flow at the open ends of the sleeve to to a level required to preclude compartment pressurization beyond the allowable structure design limits.

4. The stresses imposed on the encapsulation sleeve during dynamic pressurization shall be limited to the design limits associated with "emergency condition" as stated in ASME Section III - Nuclear Power Plant Components Code, for Class I or II components.

5. The encapsulation sleeve shall be designed, constructed, and tested in accordance with the requirements of ASME Section III Code Class II or ANSI-B31.7 Class II components with the added requirement that each pass of the final assembly welds shall be non-destructively examined by surface examination techniques (i.e., liquid penetrant or magnetic particle).

6. The encapsulation sleeve shall be provided with open vent and drain pipe nipples which extend beyond the pipe insulation as a means of monitoring the encapsulated pipe section for any leaks which might develop in service.

7. The design of the encapsulation sleeve shall permit either its removal by machinery or flame cutting techniques or the replacement of encapsulated pipe seciton in the event leaks develop which require repair or replacement of the pipe.

Impingement Barrier

The following requirements shall be met for the application of an impingement barrier at design basis break locations as a means of preventing the jet to impinge on needed safeguard systems in the event of a pipe break.

1. The impingement barrier shall be designed and supported in a manner which will not introduce significant strain concentrations on the guarded pipe.

2. The piping beyond the impingement barrier shall be provided with pipe restraints which restrict its axial displacement and motion within the impingement barrier following a postulated pipe break.

3. The impingement barrier shall be designed to withstand the dynamic forces of internal pressurization, resulting from the escape of high energy fluid at the postulated pipe break location.

4. The stresses imposed on the impingement barrier during dynamic pressurization shall be limited:

   a) for membrane stresses produce by pressure, existing in the guarded pipe:

      .90 X Yield Strength.

   b) for membrane and peak bending stresses of short duration in the initial stage of pressurization:

      1.5 X .9 Yield Strength.

5. The impingement barrier shall be Type I structure. The material used shall be ASTM-A588.

6. The current rules and practices set forth in the latest edition of the following codes and standards shall govern this work:

   "AWS D1.1-72 Structural Welding Code" as published by the American Welding Society, Inc., 2501 N.W. 7th Street, Miami, Florida 33125.

   "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as published by the American Institute of Steel Construction.

<u>In-Service Inspection</u>

Pre-service and in-service inspection of pressure-retaining welds in hign energy piping within the Auxiliary Building has been, or will be, done as follows:

Pipe weld joints located within the encapsulation sleeve and therefore not accessible for subsequent in-service inspection in accordance with the requirements of ASME Section XI, In-Service Inspection Code, have been non-destructively examined and the results satisfy the acceptance criteria of Section XI.

Piping welds which are not encapsulated and are in the piping runs traversing the Auxiliary Building will be subjected to periodic in-service examination in accordance with the ASME Section XI Code Class II, Table ISC-261(b), Winter 1972 Addenda, except that the areas to be examined (as defined by the Code) shall include 100% of the welds within the inspection interval.

Local Protection of Equipment

Barriers will be provided to protect needed equipment from adverse jet-force loadings from all design bases events. The barriers provided will be shown to withstand the impingement loads, as well as the normal working loads.

## I.2.4 CRITERIA FOR PLANT OPERABILITY FOLLOWING PIPE RUPTURE

### Control Room Habitability

The control room will be maintained habitable and its equipment functional for all design bases events. Thus, the capability to bring the reactor to a cold shutdown condition from the control room will be maintained.

### Operation of Needed Equipment

Electrical equipment in the compartments which will be affected by the accident and could be required to function following the accident are capable of withstanding the steam-air environment resulting from the postulated pipe rupture. Environmental qualifications of the equipment are available in the form of prototype test data. Tables I.3-1 and I.4-1 are complete listings of the equipment required. 31

### Redundancy

The capability to mitigate the consequences of an accident and bring the reactor to a cold shutdown condition will be assured. Loss of redundancy of equipment required for a particular accident will not be permitted in the protection system (as defined in IEEE-279) and Class IE electrical system (as defined in IEEE-308), or for engineered safety features equipment, cable penetrations and their interconnecting cables. 31

Environmentally-induced failures caused by a leak or rupture which would not in itself result in protective action but may disable protective function will also be considered. In this regard, a loss of redundancy will be permitted but a loss of function will not be permitted. For such situations the capability for bringing the plant to cold shutdown will be assured.

Separation Criteria

Separation criteria for cable systems will be identical to that described in Section 8.3.11.

Emergency Procedures

General emergency procedures will allow for evaluation of the specific incident and determination of appropriate actions to be taken to achieve a safe shutdown condition. Prompt achievement of hot shutdown will be assured automatically by adherence to the aforementioned criteria and maintenance of hot shutdown will be accomplished by adherence to general emergency procedures. These procedures will also allow for placing the reactor in a cold shutdown condition.

## I.3 MAIN STEAM LINE ROUTING AND RUPTURE EVALUATION

### I.3.1 ROUTING DESCRIPTION

The Main Steam piping from Steam Generator No. 11 exits from the southwest quadrant of containment on the Mezzanine Floor whereupon it enters the stopcheck and check (isolation) valves and anchor block assembly. The pipe then rises to the Operating Floor where it turns northward and runs horizontally through the Auxiliary Building and into the Turbine Building. The Main Steam pipe from Steam Generator No. 12 exits from the northwest quadrant of containment on the Mezzanine Floor and rises vertically to the Operating Floor where the stopcheck and check (isolation) valves and anchor block are located. Steam Line No. 12 then rises to elevation 747' where it turns northward and runs horizontally parallel to pipe No. 11, through the Auxiliary Building and into the Turbine Building.

The above routing is shown isometrically on Fig. I.3-1. This isometric also shows all branch connections to the 30" Main Steam headers as well as the entire run of the 20" equalizing line near the turbine.

### I.3.2 DESIGN BASES BREAKS

Description of Break Locations

Potential design basis pipe break locations are as shown on the Main Steam Isometric, Fig. I.3-1, and as described below. The stresses for the main steam piping system were calculated with the aid of a computer program using general flexibility and response spectra model analysis techniques. The combined stress values due to thermal expansion, pressure, weight, and seismic loading conditions have been computed.

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Postulated design basis break locations outside containment have been determined on the basis of calculated stress values and the criteria given in Section I.2.1 for Code Class 2 and 3 piping breaks. These consist of:

A. The terminal points of the main steam lines at the turbine stop valves in the Turbine Building and the anchor elbow inside containment.

B. Branch point connections in the main steam line for the atmospheric steam dump lines, the moisture separator and condenser steam dump lines, the auxiliary feedwater steam turbine lines, the equalizing line, and risers to safety valve and relief valve headers.

C. Two additional points having the highest calculated stress values in each main steam line, and the 20" equalizing line.

31 Only one of the points of the calculated stress values exceed $0.8S_A$ or $0.8\ (S_h + S_A)$. The two intermediate large break locations have been selected on the basis of their having the highest calculated stress values.

## Required Equipment

The equipment required for a design basis break in the main steam line is given in Table I.3-1. Operability of this equipment provides for reactor trip and the capability to maintain the reactor at hot shutdown after the break as well as ultimately achieving cold shutdown. Required equipment includes associated piping, cables and structures required for the equipment to perform its function.

The system of a steam line has been analyzed in Section 14.2.5 and provides the basis for generating Table I.3-1. The capability of the auxiliary feedwater system to provide adequate decay heat removal is discussed in Sections 6.6.3 and 14.1.10 and shown in Figures 14.1-46(a) and 14.1-46(c).

## Protection from Potential Pipe-Whip Damage

Pipe rupture restraints will be provided, if required, in order to protect required equipment listed in Table I.3-1.

## Protection from Jet Impingement

Impingement barriers or guardpipes will be provied, where required, in order to protect the needed equipment listed in Table I.3-1.

## Protection from Adverse Environmental Conditions

Ventilation penetrations will be sealed as necessary to prevent Steam Environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class 1 Area, Control Rod Drive Mechanism (CRDM) Room and Diesel Generator Rooms.

## Protection from Potential High Compartment Differential Pressure

The compartments in which mainsteam and feedwater isolation valves associated with Steam Generator 11 are located appends the southwest quadrant of the Reactor Building and are a part of the Category I Ventilation Zone. The compartments are housed in a seismic Class I structure. The compartment for the main steam isolation valves is between the mezzanine and operating floors while the feedwater isolation valves are in a compartment between the operating and fuel handling floors. Both compartments are contiguous with the Reactor Building.

The compartments in which the Main Steam and Feedwater isolation valves from Steam Generator 12 are located append the Northern quadrant of the Reactor Building and are a part of Category I Ventilation Zone. The compartments located within the Auxiliary Building structure are contiguous with the Reactor Building at all levels.

Openings to the outdoor atmosphere will be provided through the existing exterior walls to the extent necessary to reduce the resultant compartment pressure of a high-energy line rupture to a tolerable limit. The existing modified structure will be analyzed to assure structural integrity for all applicable environmental load conditions.

All communicating avenues including wall and floor openings and doors will be reviewed and modified as necessary to maintain Category I integrity from a high-energy line rupture outside the zone.

## I.3.3 DESIGN BASIS CRACK

Description

The orientation and location of a design basis crack can be anywhere along the piping shown on the Main Steam Isometric, Fig. I.3-1.

Required Equipment

The equipment required to place the reactor in a cold-shutdown condition is shown in Table I.3-1. Required equipment includes associated piping, cabling and structures required for the equipment to perform its functions.

Protection from Potential Pipe Whip Damage

No additional pipe restraints are required.

Protection from Jet Impingement

31 Impingement barriers are provided in order to protect the needed equipment listed in Table I.3-1. In addition, all reactor protection systems routed within the Auxiliary Building are protected in a like manner from the effects of jet impingement and/or adverse environment.

Protection from Environmental Conditions

Required equipment exposed to environmental conditions are analyzed for their capacity to perform their function and will be qualified to perform in the anticipated environment.

## I.4 FEEDWATER ROUTING AND RUPTURE EVALUATION

### I.4.1 ROUTING DESCRIPTION

The 16" discharge of each main feedwater pump is routed through a check valve, motor operated valve and feedwater heater before joining in the Turbine Building into a single 22" line. Before entering the Auxiliary Building, the Feedwater Line bifurcates into two 16" lines - one for each steam generator. The line to Steam Generator No. 11 enters the Auxiliary Building on the Operating Floor running in a southerly direction parallel to main steam line 11, before entering containment in the southwest quadrant. The line to Steam Generator No. 12 enters the Auxiliary Building on the Operating floor running in a southerly direction parallel to main steam line 12, before entering containment in the northwest quadrant. Each line is provided with a flow nozzle, control valve, motor operated isolation valve and anchor block before entering containment.

### I.4.2 DESIGN BASES BREAKS

Description of Break Locations

Postulated design basis pipe break locations are as shown on the Feedwater Isometric, Fig. I.4-1. These locations have been determined on the basis of calculated stress values based on the as-built system and the criteria given in Section I.2.1 for Code Class 2 and 3 piping breaks.

These consist of:

A. The terminal points which are located at the high pressure feedwater heaters, and the anchor elbow inside containment.

B. Branch point connections for the 4" feedwater control valve by-pass lines, and the feedwater heater by-pass lines.

C. Two additional points having the highest calculated stress values in the main feedwater lines to each steam generator.

At no point do the calculated stress values exceed $0.8 S_A$ or $0.8 (S_h + S_A)$. The two intermediate large break locations have | 31 been selected on the basis of their having the highest calculated stress values. Some of these points correspond with branch point connections.

Required Equipment

31 The equipment needed for a design basis break in the feedwater line is given in Table I.4-1. The loss of feedwater has been analyzed in Section 14.1.10 and provides the basis for generating Table I.4-1. Operability of this equipment provides for reactor trip and the capability to place and maintain the reactor in a cold shutdown condition. Required equipment includes associated piping, cables, and structures required for the equipment to perform its function.

Protection from Potential Pipe Whip Damage

Pipe Rupture restraints will be provided, where required, in order to protect required equipment listed in Table I.4-1.

Protection from Jet Impingement

31 Impingement barriers will be provided, where required, in order to protect the required equipment listed in Table I.4-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations will be sealed as necessary to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area
31 CRDM Room, and Diesel Generator Rooms (see Section I.A.1.6).

### I.4.3 Design Basis Cracks

Description

The orientation and location of a design basis crack can be anywhere along the piping shown on the feedwater isometric, Fig. I.4-1.

Required Equipment

The equipment required to place the reactor in a cold-shutdown condition is given in Table I.4-1. Required equipment includes associated piping, cabling, and structures required for the equipment to perform it function.

Protection from Potential Pipe Whip Damage

No additional pipe restraints are required.

Protection from Jet Impingement

Impingement barriers or guard pipes will be provided, where required, in order to protect the needed equipment listed in Table I.4-1.

Protection from Environmental Conditions

Required equipment exposed to environmental conditions resulting from small breaks will be analyzed for their capability to perform their function and will be qualified to perform in the anticipated environment.

### I.4-4 Flooding

The Class I areas of the Auxiliary Building were surveyed for non-Class I piping whose failure might furnish a flooding potential. Only those systems having access to large water volumes and/or potentially large flow rates were considered:

a. The main feedwater system - maximum of 200,000 and 28,000 GPM;

b. The fire protection system - unlimited supply and maximum flow of 4000 GPM.

The total water volume of the feedwater system would not flood the Class I areas of the Auxiliary Building to a level sufficient to endanger any equipment required for safe reactor shutdown. The maximum (4000 GPM) discharge from a ruptured fire protection line raises the water level in various building sumps at the rate of 0.13 in./min., permitting the operator to isolate the broken line before damaging flooding occurs. Numerous sump-level alarms forewarn the operating staff of potential flooding.

In addition, the building was examined for any potential damage to the required equipment due to the cascading water as it passes through floor penetrations and stairwells toward the ground floor. The floor drains, openings and stairwells are located such that no water will drip down on required equipment from the floor above.

## I.5 CVCS LETDOWN LINE ROUTING AND RUPTURE EVALUATION

### I.5.1 ROUTING DESCRIPTION

The Letdown System enters the Auxiliary Building from containment through a penetration on the Mezzanine elevation into compartment D. The line is provided with an isolation valve adjacent to its penetration as well as isolation valves inside containment. The letdown line is then routed to the letdown heat exchanger, which is located in a compartment on the Mezzanine elevation adjacent to compartment D.

### I.5.2 DESIGN BASIS BREAKS

Description of Break Locations

Postulated design basis pipe break locations are as shown on the Letdown Line Isometric, Figure I.A-2. These locations have been determined on the basis of calculated stress valves based on the as-built system and criteria given in Section I.2.1 for code Class 2 and 3 piping breaks.

These consist of:

A. The terminal points which are located at the containment penetration on the Auxiliary Building side an intermediate anchor and the letdown heat exchanger.

B. A 3/4" branch connection for line purge

C. Two additional points between each set or anchor locations that have the highest calculated stress valves.

As no point do the calculated stress valves exceed $0.8\ S_A$ or $0.8(S_h + S_A)$, and that the intermediate large break locations have been selected on the basis of their having the highest calculated stress valves.

Required Equipment

The equipment needed for a design basis break in the letdown line is given in Table I.5-1. The rupture of the letdown line has been analyzed in Section 14.3 and 9.2 and provides the basis for generating Table I.5-1. Operability of this equipment provides for reactor trip and the capability to place and maintain the reactor in a cold shutdown condition. Required equipment includes associated piping, cables and structures required for the equipment to perform its function.

Protection from Potential Pipe Whip Damage

Pipe rupture restraints are provided to protect the required equipmetn listed in Table I.5-1.

Protection from Jet Impingement

Impingement barriers are provided to protect the required equipment listed in Table I.5-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all other penetrations sealed to prevent any adverse environment from effecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area, Control Rod Drive Mechanism (CRDM) Room and Diesel Generator Rooms.

## I.5.3 DESIGN BASIS CRACKS

Description

The orientation and location of a design basis crack can be anywhere along the piping shown on the Letdown Isometric, Fig. I.A-2.

Required Equipment

The equipment required to place the reactor in a cold-shutdown condition is given in Table I.5-1. Required equipment includes associated piping, cabling and structures required for the equipment to perfor it functions.

Protection from Potential Pipe Whip Damage

No additional pipe restraints are required.

Protection from Jet Impingement

Impingement barriers are provided to protect the needed equipment listed in Table I.5-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all penetrations sealed to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area CRDM Room and Diesel Generator Rooms.

## I.6 STEAM GENERATOR BLOWDOWN LINE ROUTING AND RUPTURE EVALUATION

### I.6.1 ROUTING DESCRIPTION

The Steam Generator Blowdown lines enter the Auxiliaty Building from containment through a penetration on the mezzanine elevation into compartment C. Each line is provided with an isolation valve adjacent to its penetration as well as an isolation valve inside containment. The Blowdown line is then routed on the mezzanine to the Blowdown flash tank, which is located in a compartment on the mezzanine elevation adjacent to compartment D.

### I.6.2 DESIGN BASIS BREAKS

Description of Break Locations

Postulated design basis pipe break locations are as shown on the Blowdown Isometric, Fig. I.A-1. These locations have been determined on the basis of calculated stress values based on the as-built system and the criteria given in Section I.2.1 for Code Class 2 and 3 piping breaks.

These consist of:

A. The terminal points which are located at the containment penetration on the Auxiliary Building side, an intermediate anchor and the Blowdown flash tank.

B. Two additional points between each set of anchor locations that have the highest calculated stress valves.

At no points do the calculated stress values exceed $0.8S_A$ or $0.8\ (S_h + S_A)$. The two intermediate large break locations have been selected on the basis of their having the highest calculated stress values.

Required Equipment

The equipment needed for a design basis break in the steam generator blowdown lines is given in Table I.6-1. The rupture of the blowdown line is similar to a small break in the main steam line and has been analyzed as such and provided the basis for generating Table I.6-1. Operability of this equipment provides for reactor trip and the capability to place and maintain reactor in a cold shutdown condition. Required equipment includes associated piping, calbes and structures required for the equipment to perform its function.

Protection from Potential PIpe Whip Damage

Pipe Rupture restraints are provided to protect the required equipment listed in Table I.6-1.

Protection from Jet Impingement

Impingement barriers are provided to protect the required equipment listed in Table I.6-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all penetration sealed to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room Class I Areas CRDM Room and Diesel Generator Rooms.

I.7.3 DESIGN BASIS CRACKS

Description

The orientation and location of a design basis crack can be anywhere along the piping shown on the Blowdown Isometric, Fig. I.A-1.

Required Equipment

The equipment required to place the reactor in a cold-shutdown condition is given in Table I.6-1. Required equipment includes associated piping, cabling and structures required for the equipment to perform it functions.

Protection from Potential Pipe Whip Damage

No additional pipe restraints are required.

## Protection from Jet Impingement

Impingement barriers are provided to protect the needed equipment listed in Table I.6-1.

## Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all penetrations sealed to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area CRDM Room and Diesel Generator Rooms.

## I.7 STEAM SUPPLY TO AUXILIATY FEEDWATER PUMP TURBINE LINE ROUTING AND RUPTURE EVALUATION

### I.7.1 ROUTING DESCRIPTION

The steam supply to the Auxiliary Feedwater Pump Turbine (AFWPT) from steam generator II originates in compartment Y at a main steam line branch connection up-steam of the main steam isolation valves. The line is then routed through compartments X and B where it joins the supply from steam generator 12 and proceeds down to the Auxiliary Feedwater Pump Room in the Class I area of the Turbine Building. The supply from Steam Generator 12 originates in compartment B at a main steam line branch connection up-stream of the main steam isolation valves.

### I.7.2 DESIGN BASIS BREAKS

Description of Break Locations

Postulated design basis pipe break locations are as shown on the Auxiliary Steam Isometric, Fig. I.7-1. These locations have been determined on the basis of calculated stress values based on the as-built system and the criteria given in Section I.2.1 for Code Class 2 and 3 piping breaks.

These consist of:

A. The terminal points which are located at their branch connection on the main steam lines, intermediate anchor locations and the AFWPT throttle valve.

B. Two additional points between each set of anchors locations that have the highest calculated stress valves.

At no point do the calculated stress values exceed $0.8S_A$ or $0.8\ (S_A + S_A)$, and that the two intermediate large break locations have been selected on the basis of their having the highest calculated stress values.

Required Equipment

The equipment needed for a design basis break in the steam supply to the Auxiliary feedwater pump turbine line is given in Table I.7-1. The rupture of this line is similar to a small steam line break and has been analyzed as such and provided the basis for generating Table I.7-1. Operability of this equipment provides for reactor trip and the capability to place and maintain reactor in a cold shutdown condition. Required equipment includes associated piping, cables and structures required for the equipment to perform its function.

The auxiliary feedwater pump turbine line will be totally encapsulated throughout its traverse through the auxiliary feedwater pump room thus precluding any steam environment from affecting the required equipment in the room. In addition, the exclusion of an adverse environment from the compartment ensures the single failure criterion discussed in Section 10.3.3 is valid.

Protection from Potential Pipe Whip Damage

Pipe Rupture restraints are provided, to protect required equipment listed in Table I.7-1.

Protection from Jet Impingement

Impingement barriers are provided to protect the required equipment listed in Table I.7-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all penetrations sealed to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area CRDM Room and Diesel Generator Rooms.

## I.7.3 DESIGN BASIS CRACKS

Description

The orientation and location of a design basis crack can be anywhere along the piping shown on the Auxiliary Feedwater Isometric, Fig. I.A-3.

Required Equipment

The equipment required to place the reactor in a cold-shutdown condition is given in Table I.7-1. Required equipment includes associated piping, cabling and structures required for the equipment to perform it functions.

Protection from Potential Pipe Whip Damage

No additional pipe restraints are required.

Protection From Jet Impingement

Impingement barriers are provided to protect the needed equipment listed in Table I.7-1.

Protection from Adverse Environmental Conditions

Ventilation penetrations are provided with redundant dampers and all penetrations sealed to prevent the steam environment from affecting required equipment located within the Control Room Air Conditioning Room, Control Room, Relay Room, Class I Area CRDM Room and Diesel Generator Rooms.

## I.8 EMERGENCY PROCEDURES

The emergency procedures listed below are general in nature since it is deemed appropriate to allow for assessment of the incident prior to ultimately bringing the reactor to cold shutdown.

### I.8.1 MAIN STEAM LINE RUPTURE

Design Basis Breaks

For the design basis (double ended rupture of the largest steam pipe), safety injection would be actuated by low steam line pressure in the affected steam line. Either high-high steam flow or high steam flow plus low-low $T_{avg}$ will initiate automatic closure of the main steam line stop valves. The actuation of safety injection would initiate a reactor trip.

Safety injection actuation will also initiate automatic start of the motor driven and turbine driven auxiliary feed pumps.

Following initiation of safety injection, the safety injection pumps will deliver highly concentrated boric acid (20,000 ppm) from the boric acid tank which will insert sufficient reactivity to bring the reactor to a safe cold shutdown condition, as discussed in Section 6. Following the delivery of the 20,000 ppm boric acid, the safety injection pumps will deliver water from the refueling water storage tank at a boron concentration of 2,000 ppm.

For the design basis steam line break, the following equipment will be available to accomplish safety functions:

1) Safety injection to pump borated water into the core, thereby limiting the core power transient following the break and bringing the reactor to a subcritical condition.

2) Closure of the main steam stop valves in the event of a break in any of the piping downstream of the steam line check and stop valves. This action is required to limit the reactor coolant system cooldown.

3) Isolation of main feedwater to the steam generators to limit the reactor coolant system cooldown. Isolation of main feedwater is redundantly accomplished by closing the main feedwater control valves, tripping the main feed pumps, and closing the main feedwater pump discharge valves.

4) Following reactor trip, feedwater will be required in the worst case in abount 10 minutes to dissipate decay heat. In the event of a concurrent blackout, at least one auxiliary feed pump would be available to remove decay heat.

After the affected steam generator has emptied or after the break has been isolated, the auxiliary feedwater system and main steam power-operated relief valves will provide the heat removal capability for reducing the temperature of the reactor coolant system. The residual heat removal system would then normally be used to cool the plant to a safe cold shutdown condition. However, the auxiliary feedwater system along with the secondary side power operated relief valves can be used to bring the platn to a safe shutdown condition, but this would require a much longer time than with the use of the residual heat removal system.

Westinghouse has reviewed a series of steam line breaks ranging from small breaks up to and including the double ended rupture of a steam line outside the containment. It has been determined from this review that the double ended steam line break as analyzed in Section 14 represents the worst cooldown accident and is more severe than a small steam line crack (of the order of 100'lbs/sec at 100 psig regradles of power level), even assuming the main feedwater control valves fail fully open as a result of the environment resulting from the small steam release.

As described in Section 14, the plant is designed to accept the steam line rupture outside the containment with concurrent loss of off-site power (diesel power available only) and a single active failure in a required system.

For small steam line breaks at power which do not cause the reactor power to reach a point at which an immediate reactor trip would occur, no reactor core safety limit will be violated. The small break will result in a continued loss of water from the secondary side of the plant and will eventually result in the emptying of the condenser hot well. Emptying the hotwell will result in a loss of main feedwater and the reactor will be tripped on low-low steam generator level coincident with feed/steam flow mismatch. After the trip, steam release through the break will cause reactor coolant system cooldown. The cooldown would occur until the steam generator feeding the break empties. The cooldown would occur until the steam generator feeding the break empties. The cooldown will automatically initiate safety injection on either low pressurizer pressure and level or low steam line pressure. Initiation of safety injection will isolate all main feedwater by tripping closed the main feedwater control valves, tripping the main feedwater pumps, and tripping closed the main feedwater pump discharge valves. Following initiation of safety injection, the safety injection pumps will deliver highly concentrated boric and (20,000 ppm) from the boric acid tanks which will insert sufficient reactivity to bring the reactor to a safe shutdown condition. Following this, the sequence of events is essentially identical to that presented above for the large steam line break. The equipment required to bring the plant to a cold shutdown condition is identical with that required for the large break.

Should the plant be at hot standby or subcritical at the time of a small steam line break, the plant will be cooled down and safety injection will be actuated on low pressurizer pressure and level or low steam line pressure. Following this, the sequence of events will be identical to that described above.

However, the operator would have other alternate systems available to him following the incident to facilitate an orderly shutdown of the reactor. Hence the method and procedure to be used for shutdown will be determined by the operator based on the equipment available to him.

## I.8.2 FEEDWATER LINE RUPTURE

<u>Design Basis Breaks</u>

In the unlikely event of a design basis break in a main feedwater line, the reactor will be automatically tripped and the safety injection sequence initiated due to low-low steam generator level or steam flow-feedwater flow mismatch with coincident low steam generator water level. As described in Section 6.6, the Auxiliary Feedwater System and the Steam Generator safety valves

## I.9 DESCRIPTION OF PIPE-WHIP DYNAMIC ANALYSIS

Restraints will be provided to prevent pipe-whip where there is any possibility that whip following a pipe rupture would damage systems, components or structures that are needed to mitigate the consequences of that pipe rupture.

A nonlinear elastic-plastic analysis is performed to evaluate the adequacy of the pipe rupture restraint system to provide protection following postulated circumferential and longitudinal pipe breaks. The coupled nonlinear dynamic analysis of the restraint-piping system will account for the dynamic nature of the rupture force, the elastic-plastic deformation of the pipe restraint system, and the impact effects resulting from clearance between the restraint and pipe.

The results of the analysis includes identification of plastic hinges formed in the pipe, strain in hinges, and restraint status including gap closure, elastic or plastic deformation and reacting loads.

### I.9.1 METHODS OF ANALYSES

Blowdown forces imposed on the piping system and the resultant effects of pipe whip are determined using the methods outlined below.

#### Blowdown Forces

Blowdown forces resulting from pipe rupture are determined using a computer program based on RELAP 3 the AEC's presently accepted loss of coolant accident program. The program computes and plots the force-time history curve of the reaction loads resulting from a circumferential or longitudinal pipe break for subcooled liquid,flashing liquid and steam system.

The system of interest is modeled as an assembly of volumes connected by flow paths. In a flow path there can be inserted a valve, check valve, or pump. The program solves the transient energy, momentum, and state equations for the volumes and flow paths. The program has the capability to solve the state equation for subcooled water, two phase steam-water mixtures, and superheated steam. The ASME Steam Tables are tabulated within the program, and table lookup methods are used to determine the state within each volume. An optional bubble separation model can be used to represent a vapor phase above a liquid phase (e.g., steam generator). The program calculates the flow in each junction using both an inertial model (no-choking) and a critical flow model (choking). The lower of the flows calculated from the two above models is limiting and thus taken as the actual flow.

The program will allow for the modeling of special component characteristics as applicable in different systems. Leaks can be opened instantaneously or as a function of time. Pumps can continue to operate or can coastdown. Valves can be opened or closed, and check valves follow a prescribed pressure loss, flow characteristic.

The break force is calculated using the one dimensional momentum equation. The force on the piping consists of the following three forces:

$$\text{Pressure force} = (P_t - P_e)A \text{ (zero for nonchoking flow)}$$

$$\text{Momentum force} = \rho \frac{AV^2}{g}$$

$$\text{Momentum change} = \frac{\Delta(mV)}{\Delta t g} \text{ (zero for steady state)}$$

where: $P_t$ = throat pressure

$P_e$ = exit pressure

$A$ = break area

$\rho$ = density

$V$ = velocity

$g$ = 32.2 lbm ft/lbf sec$^2$

$m$ = mass

$t$ = time

The algebraic sum of the three forces is the resultant force on the broken piping.

Effects of Pipe Whip

Computation of piping system response to pipe rupture forces are determined with a computer program using an adaptation of the finite element method to the specific requirements of pipe rupture analysis. A dynamic response - time history of the piping system is determined which includes elastic-plastic pipe behavior and non-linear effects of pipe rupture restraints.

The piping system is modeled as an assemblage of straight and curved beams (elbows) connecting discrete nodal points. Weight of the piping system (including offset weights of valve motor operators) is "lumped" as selected nodal points. The blowdown force vs. time history as developed by the previously discussed transient flow analysis computer program is then applied as an excitation force to the appropriate piping node point. Dynamic response of the piping system is computed at iterative increments of time and includes forces, moments, deflections and rotations at each node. The resulting bending and torsional moments at each node are used to predict both initial yielding (at which time the elastic modulus at the affected point is replaced by the strain hardening modulus) and ultimate load (f.e., formation of a plastic hinge: after which the modulus is set to a very low value). In situations where stress reversal occurs, an isotropic strain hardening model is used. The strain in plastic hinges and deflections of node points are used to identify pipe trajectory.

Pipe rupture restraints are modeled with initial design gaps, and then both alastic and plastic moduli. At each time step, the programs will thus determine gap closure, elastic or plastic deformation, and the resulting impact load.

A model of the main steam lines is shown in Figure I.9-1.

## I.10 DESCRIPTION OF COMPARTMENT PRESSURE DIFFERENTIAL ANALYSIS

The widely used CONTEMPT code is used to determine the local pressure on building walls and floor, and compartment temperatures. Modifications have been made to the code to analyze a group of connected compartments to determine the transient conditions. The blowdown is assumed to occur when the reactor coolant system is at hot standby with the steam generator pressure at 1000 psig. The blowdown rate and duration depend on the break location and size. In the case of small breaks, the steam pressure, flow and enthalpy are assumed to be constant due to continuous heat transfer from the reactor coolant system. 31
Exposed steel and concrete are considered as heat sinks, and individual fan-coil units and normal ventilation are used for heat removal when available.

In the compartment where pipe rupture occurs, the mass and energy input rates are based on the blowdown for the specific break. The initial conditions of all compartments are identical. A sequence of calculations is performed to determine the mass and energy transferred between compartments for a short time interval. The time interval is carefully selected to assure that the solution for compartment pressure transients converges. The sequence begins in the compartment where the break occurs by evaluating the mass and energy input rates at the midpoint of a time interval and adding these increments to the current amounts in the compartment. An intermediate state is then obtained by applying energy- and mass-balance equations to the total contents of the compartment. No discharge or outflow is assumed to take place at this intermediate phase of the calculation.

The intermediate state in the break compartment, the adjacent compartment conditions at the beginning of the time interval, and the flow geometry, determine the amount of steam and air to be discharged to adjacent compartments. The final state of the break compartment, after a portion of steam and air has been discharged, is obtained again by an energy and mass balance. The same calculational procedures are repeated for each adjacent compartment.

## I.11 DESCRIPTION OF JET IMPINGEMENT LOAD ANALYSIS

The jet impingement load is defined as the load on a component (piping, equipment or structure) of the undeflected jet from an instantaneous circumferential or longitudinal break in a high-energy pipe.

At the point of rupture, the jet pressure is assumed equal to the exit pressure ($P_e$) which corresponds to the critical flow rate in a single or two-phase flow regime, and the jet area is assumed to be the effective break area (A). For pipes initially containing steam, the jet flow away from the point of rupture is assumed to diverge at an included angle (Ø) of 20°. The angle of divergence (Ø) for a jet from pipes initially containing saturated or subcooled water is determined by the expansion ratio necessary to establish equilibrium at ambient pressure, and depends on the initial fluid conditions. Hence, the area of the jet at some distance from the point of a longitudinal break is:

$$A_i = [L_1/2 + (L_3/2) \tan(\emptyset/2)] \; [L_2/2 + (L_3/2) \tan(\emptyset/2)]\pi$$

where:

$L_1$ = width of break

$L_2$ = length of break

$L_3$ = distance to target

Ø = divergence angle

The 2-phase maximum impingement pressure along the jet centerline is:

$$P = \frac{U_f^2}{2 g_c V_f}(1-\alpha) + (P_0 - P_{static})\alpha$$

where:

$U_f$ = Velocity of the liquid phase at a distance d from the rupture plane. $U_f$ is determined through application of experimental data for critical free jet flow.



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$V_f$ = Specific volume of the liquid phase in a two-phase mixture at a pressure of $P_{static}$.

$P_{static}$ = The static pressure of the fluid in the jet, which is identical with the ambient pressure in the sub-sonic region of the jet.

$P_o$ = The isentropic stagnation pressure corresponding to the mach number of the local fluid at a distance d from the rupture.

$\alpha$ = The vapor volume fraction for a two-phase mixture (volume of the vapor divided by volume of the fluid).

The average jet pressure at some distant target is:

$$P_i = P\, C_{ave}$$

where:

$C_{ave}$ = averaging factor based on experimental velocity profiles = 1.0, use of which is the worst case.

The effective load on a distant target is:

$$F_e = f\, P_i A_e$$

where:

$A_e$ = projected area of the target object.

f = shape factor to account for deflection, rather than stagnation, of the jet. The only value used is unity.

Based on the effective jet impingement load as determined, each target was identified and the necessary protection was provided. These targets are the walls, cables and cable trays, and instrumentation.

## I.12 CONTAINMENT INTEGRITY

The present anchor block and restraint system design precludes any functional damage to the Containment Vessel and Shield Building or to any penetrations, seals, and ESF-related piping or cables due to any of the previously described postulated breaks.

REQUIRED EQUIPMENT LIST FOR MAIN STEAM LINE BREAK OR CRACK

UNIT 1
COMPARTMENT LOCATION
FIGURE I.A-18

A. MECHANICAL EQUIPMENT

| | |
|---|---|
| **Safety Injection Pumps 1A, 1B,(2A & 2B) | E * |
| Auxiliary Feedwater Pumps 11, 12,(21 & 22) | TB * |
| Diesel Cooling Water Pumps 12 &(22) | SH * |
| Cooling Water Pump Strainers 11, 12,(21 & 22) | SH * |
| Diesel Generators 11 & 12 With Auxiliaries | *** |
| Control Room Ventilation System 121 & 122 | *** |

B. VALVES

| | VALVE | MCC | |
|---|---|---|---|
| **32079 (32182) SIS Pump Suction From RWST | E * | E * | |
| **32080 (32183) SIS Pump Suction From RWST | E * | E * | |
| **32081 (32184) SIS Pump Suction From Boric Acid Tanks | E * | E * | |
| **32082 (32185) SIS Pump Suction From Boric Acid Tanks | E * | E * | |
| 32025 (32030) AFWP 11 (22) Suction From Cooling Water | TB * | TB * | |
| 32027 (32026) AFWP 12 (21) Suction From Cooling Water | TB | TB * | 31 |
| 32264 (32265) AFWP 11 (22) Steam Supply | TB | TB * | |
| 31059 (31060) AFWP 11 (22) Steam Supply Throttle Valve | TB | TB * | |
| 32023 (32038) Steam Gen. 11 (21) Feedwater Isolation | X | E (X) * | |
| 32024 (32029) Steam Gen. 12 (22) Feedwater Isolation | B | E (X) * | |
| 31098 (31116) Main Stream Isolation Valve 11 (21) | Y | | |
| 31099 (31117) Main Steam Isolation Valve 12 (22) | B | | |
| **31084 (31102) Atmospheric Relief Valve 11 (21) | Y | | |
| **31089 (31107) Atmospheric Relief Valve 12 (22) | A | | |
| **31231 (31233) Pressurizer Relief Valve | * | | |
| **31232 (31234) Pressurizer Relief Valve | * | | |

C. ELECTRICAL COMPONENTS

The controls, power and protection for the mechanical equipment previously listed as well as:

| | |
|---|---|
| Reactor Trip Breakers | B * |
| Batteries 11, 12,(21 & 22) | TB * |
| 480 Volt Buses 110, 120,(210 & 220) | B * |
| 4160 Volt Buses 15, 16,(25 & 26) | TB * |

( ) Unit 2

TB - Turbine Bldg.

SH - Screen House

(X) - RELOCATED

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TABLE I.3-1

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| D. INSTRUMENTATION | Location |
|---|---|
| Steam Generator 11 (21) Pressure PT-468, 469 & 482 | Y |
| Steam Generator 12 (22) Pressure PT-478, 479 & 483 | C |
| Steam Generator 11 (21) Level LT-461, 462 & 463 | * |
| Steam Generator 12 (22) Level LT-471, 742 & 473 | * |
| **Boric Acid Tank 11 (12) Level LT-106, 172 & 190 *** | * |
| **Boric Acid Tank 121 Level LT-102, 171 & 189 *** | * |
| Steam Generator 11 (21) Steam Flow FT-464 & 465 | * |
| Steam Generator 12 (22) Steam Flow FT-474 & 475 | * |
| RCS Loop A Hot Leg Temperature TE-402A, 404A,* 406A & 408A | * |
| RCS Loop A Cold Leg Temperature TE-402B, 406B & 408B | * |
| 31 RCS Loop B Hot Leg Temperature TE-401A, 403A, 405A & 407A | * |
| RCS Loop B Cold Leg Temperature TE-401B, 403B, 405B & 407B | * |
| Power Range Nuclear Instrumentation NC-41, 42, 43 & 44 | * |
| Pressurizer Pressure PT-429, 430 & 431 | * |
| Pressurizer Level LT-426, 429 & 428 | * |

| E. VENTILATION DAMPERS (CONTROL ROOM) | |
|---|---|
| 34177 (34176) Outside Air Inlet | * |
| 34145 (34142) Outside Air Inlet to Air Conditioner | * |
| 34144 (34143) Air Conditioner Outlet | * |
| 34180 (34178) Outside Air Inlet to PAC Filter | * |
| 34181 (34179) Recirculation inlet to PAE Filter | * |
| 34183 (34182) PAC Filter Outlet | * |

Notes:

** These items are not required to function immediately, due to a design basis crack, but will be used during subsequent operation to achieve a cold shutdown condition.

*** A fourth level channel will be provided for each boric acid storage tank; however, only one channel will be required for indication to achieve cold shutdown.

* Outside those areas which experience a steam environment for this accident

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## REQUIRED EQUIPMENT FOR FEEDWATER LINE BREAK OR CRACK

| | UNIT 1 COMPARTMENT LOCATION FIGURE I.A-18 | |
|---|---|---|
| **A. MECHANICAL EQUIPMENT** | | |
| **Safety Injection Pumps 1A, 1B,(2A & 2B) | E * | |
| Auxiliary Feedwater Pumps 11, 12,(21 & 22) | TB * | |
| Diesel Cooling Water Pumps 12 &(22) | SH * | |
| Cooling Water Pump Strainers 11, 12,(21 & 22) | SH * | |
| Diesel Genrators 11 & 12 With Auxiliaries | *** | |
| Control Room Ventilation System 121 & 122 | *** | |
| **B. VALVES** | **VALVE** | **MEL** |
| **32079 (32182) SIS Pump Suction From RWST | E * | E * |
| **32080 (32183) SIS Pump Suction From RWST | E * | E * |
| **32081 (32184) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| **32082 (32185) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| 32025 (32030) AFWP 11 (22) Suction From Cooling Water | TB * | TB * |
| 32027 (32026) AFWP 12 (21) Suction From Cooling Water | TB * | TB * |
| 32264 (32265) AFWP 11 (22) Steam Supply | TB | TB * |
| 31059 (31060) AFWP 11 (22) Steam Supply Throttle Valve | TB | TB * |
| 32023 (32038) Steam Gen. 11 (21) Feedwater Isolation | Y | E(X) * |
| 32024 (32029) Steam Gen. 12 (22) Feedwater Isolation | B | E(X) * |
| 31098 (31116) Main Stream Isolation Valve 11 (21) | Y | |
| 31099 (31117) Main Steam Isolation Valve 12 (22) | B | |
| **31084 (31102) Atmospheric Relief Valve 11 (21) | Y | |
| **31089 (31107) Atmospheric Relief Valve 12 (22) | A | |
| **31231 (31233) Pressurizer Relief Valve | * | |
| **31232 (31234) Pressurizer Relief Valve | * | |

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**C. ELECTRICAL COMPONENTS**

The controls, power and protection for the mechanical equipment previously listed as well as:

| | |
|---|---|
| Reactor Trip Breakers | B * |
| Batteries 11, 12,( 21 & 22 ) | TB * |
| 480 Volt Buses 110, 120,( 210 & 220 ) | B * |
| 4160 Volt Buses 15, 16,( 25 & 26 ) | TB * |

( ) UNIT #2
TB - Turbine Building
SH - Screen House
(X)- Relocated

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| D. INSTRUMENTATION | LOCATION |
|---|---|
| Steam Generator 11 (21) Pressure PT-468, 469 & 482 | * |
| Steam Generator 12 (22) Pressure PT-478, 479 & 483 | C |
| Steam Generator 11 (21) Level LT-461, 462 & 463 | * |
| Steam Generator 12 (22) Level LT-471, 742,& 473 | * |
| *Boric Acid Tank 11 (12) Level LT-106, 172 & 190 ** | * |
| *Boric Acid Tank 121 Level LT-102, 171 & 189 ** | * |
| Steam Generator 11 (21) Steam Flow FT-464 & 465 | * |
| Steam Generator 12 (22) Steam Flow FT-474 & 475 | * |
| Steam Generator 11 (21) Feedwater Flow FT-466 & 467 | B |
| Steam Generator 12 (22) Feedwater Flow FT-476 & 477 | B |
| *Pressurizer Level LT-426, 427 & 428 | * |
| *Pressurizer Pressure PT-429, 430 & 431 | * |

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| E. VENTILATION DAMPERS (CONTROL ROOM) | |
|---|---|
| 34177 (34176) Outside Air Inlet | * |
| 34145 (34142) Outside Air Inlet to Air Conditioner | * |
| 34144 (34143) Air Conditioner Outlet | * |
| 34180 (34178) Outside Air Inlet to PAC Filter | * |
| 34181 (34179) Recirculation inlet to PAC Filter | * |
| 34183 (34182) PAC Filter outlet | * |

Notes:

** These items are not required to function immediately, due to design basis events, but will be used during subsequent operation to achieve a cold shutdown condition.

*** A fourth level channel will be provided for each boric acid storage tank; however, only one channel will be required for indication to achieve cold shutdown.

* Outside those areas which experience a steam environment for this accident

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TABLE I.4-1

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REQUIRED EQUIPMENT LIST FOR LETDOWN LINE BREAK OR CRACK — UNIT 1

A. MECHANICAL EQUIPMENT

| | COMPARTMENT LOCATION FIGURE I.A-18 |
|---|---|
| **Safety Injection Pumps 1A, 1B,(2A & 2B) | E * |
| Auxiliary Feedwater Pumps 11, 12,(21 & 22) | TB * |
| Diesel Cooling Water Pumps 12 &(22) | SH * |
| Cooling Water Pump Strainers 11, 12,(21 & 22) | SH * |
| Diesel Generators 11 & 12 With Auxiliaries | *** |
| Control Room Ventilation System 121 & 122 | *** |

B. VALVES

| | VALVE | MCC |
|---|---|---|
| **32079 (32182) SIS Pump Suction From RWST | E * | E * |
| **32080 (32183) SIS Pump Suction From RWST | E * | E * |
| **32081 (32184) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| **32082 (32185) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| 32025 (32030) AFWP 11 (22) Suction From Cooling Water | TB * | TB * |
| 32027 (32026) AFWP 12 (21) Suction From Cooling Water | TB | TB * |
| 32264 (32265) AFWP 11 (22) Steam Supply | TB | TB * |
| 31059 (31060) AFWP 11 (22) Steam Supply Throttle Valve | TB | TB * |
| 32023 (32038) Steam Gen. 11 (21) Feedwater Isolation | X | E (X) * |
| 32024 (32029) Steam Gen. 12 (22) Feedwater Isolation | B | E (X) * |
| 31098 (31116) Main Stream Isolation Valve 11 (21) | Y | |
| 31099 (31117) Main Steam Isolation Valve 12 (22) | B | |
| **31084 (31102) Atmospheric Relief Valve 11 (21) | Y | |
| **31089 (31107) Atmospheric Relief Valve 12 (22) | A | |
| **31231 (31233) Pressurizer Relief Valve | * | |
| **31232 (31234) Pressurizer Relief Valve | * | |
| 31339 (31430) Letdown Isolation | D | E * |
| 31325 (31347) Letdown Isolation | *** | E * |
| 31326 (31348) Letdown Isolation | *** | E * |
| 31327 (31349) Letdown Isolation | *** | E * |

C. ELECTRICAL COMPONENTS

The controls, power and protection for the mechanical equipment previously listed as well as:

| | |
|---|---|
| Reactor Trip Breakers | B * |
| Batteries 11, 12,(21 & 22) | TB * |
| 480 Volt Buses 110, 120,(210 & 220) | B * |
| 4160 Volt Buses 15, 16,(25 & 26) | TB * |

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( ) Unit 2

TB - Turbine Bldg.

SH - Screen House

(X) - RELOCATED

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| | |
|---|---|
| **D. INSTRUMENTATION** | **Location** |
| Steam Generator 11 (21) Pressure PT-468, 469 & 482 | Y |
| Steam Generator 12 (22) Pressure PT-478, 479 & 483 | C |
| Steam Generator 11 (21) Level LT-461, 462 & 463 | * |
| Steam Generator 12 (22) Level LT-471, 742 & 473 | * |
| **Boric Acid Tank 11 (12) Level LT-106, 172 & 190 *** | * |
| **Boric Acid Tank 121 Level LT-102, 171 & 189 *** | * |
| Steam Generator 11 (21) Steam Flow FT-464 & 465 | * |
| Steam Generator 12 (22) Steam Flow FT-474 & 475 | * |
| RCS Loop A Hot Leg Temperature TE-402A, 404A, 406A & 408A | * |
| RCS Loop A Cold Leg Temperature TE-402B, 406B & 408B | * |
| RCS Loop B Hot Leg Temperature TE-401A, 403A, 405A & 407A | * |
| RCS Loop B Cold Leg Temperature TE-401B, 403B, 405B & 407B | * |
| Power Range Nuclear Instrumentation NC-41, 42, 43 & 44 | * |
| Pressurizer Pressure PT-429, 430 & 431 | * |
| Pressurizer Level LT-426. 429 & 428 | * |
| **E. VENTILATION DAMPERS (CONTROL ROOM)** | |
| 34177 (34176) Outside Air Inlet | * |
| 34145 (34142) Outside Air Inlet to Air Conditioner | * |
| 34144 (34143) Air Conditioner Outlet | * |
| 34180 (34178) Outside Air Inlet to PAC Filter | * |
| 34181 (34179) Recirculation inlet to PAE Filter | * |
| 34183 (34182) PAC Filter Outlet | * |

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Notes:

** These items are not required to function immediately, due to a design basis crack, but will be used during subsequent operation to achieve a cold shutdown condition.

*** A fourth level channel will be provided for each boric acid storage tank; however, only one channel will be required for indication to achieve cold shutdown.

* Outside those areas which experience a steam environment for this accident

REQUIRED EQUIPMENT LIST FOR BLOWDOWN LINE BREAK OR CRACK

UNIT 1
COMPARTMENT LOCATION
FIGURE I.A-18

A. MECHANICAL EQUIPMENT

| | |
|---|---|
| **Safety Injection Pumps 1A, 1B,(2A & 2B) | E * |
| Auxiliary Feedwater Pumps 11, 12,(21 & 22) | TB * |
| Diesel Cooling Water Pumps 12 &(22) | SH * |
| Cooling Water Pump Strainers 11, 12,(21 & 22) | SH * |
| Diesel Generators 11 & 12 With Auxiliaries | *** |
| Control Room Ventilation System 121 & 122 | *** |

B. VALVES

| | VALVE | MCC |
|---|---|---|
| **32079 (32182) SIS Pump Suction From RWST | E * | E * |
| **32080 (32183) SIS Pump Suction From RWST | E * | E * |
| **32081 (32184) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| **32082 (32185) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| 32025 (32030) AFWP 11 (22) Suction From Cooling Water | TB * | TB * |
| 32027 (32026) AFWP 12 (21) Suction From Cooling Water | TB | TB * |
| 32264 (32265) AFWP 11 (22) Steam Supply | TB | TB * |
| 31059 (31060) AFWP 11 (22) Steam Supply Throttle Valve | TB | TB * |
| 32023 (32038) Steam Gen. 11 (21) Feedwater Isolation | X | E (X) * |
| 32024 (32029) Steam Gen. 12 (22) Feedwater Isolation | B | E (X) * |
| 31098 (31116) Main Stream Isolation Valve 11 (21) | Y | |
| 31099 (31117) Main Steam Isolation Valve 12 (22) | B | |
| **31084 (31102) Atmospheric Relief Valve 11 (21) | Y | |
| **31089 (31107) Atmospheric Relief Valve 12 (22) | A | |
| **31231 (31233) Pressurizer Relief Valve | * | |
| **31232 (31234) Pressurizer Relief Valve | * | |
| 32040 (32046) Blowdown Isolation | *** | |
| 32043 (32049) Blowdown Isolation | *** | |
| 32044 (32051) Blowdown Isolation | C | |
| 32058 (32059) Blowdown Isolation | C | |

C. ELECTRICAL COMPONENTS

The controls, power and protection for the mechanical equipment previously listed as well as:

| | |
|---|---|
| Reactor Trip Breakers | B * |
| Batteries 11, 12,(21 & 22) | TB * |
| 480 Volt Buses 110, 120,(210 & 220) | B * |
| 4160 Volt Buses 15, 16,(25 & 26) | TB * |

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( ) Unit 2

TB - Turbine Bldg.

SH - Screen House

(X) - RELOCATED

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| D. INSTRUMENTATION | Location |
|---|---|
| Steam Generator 11 (21) Pressure PT-468, 469 & 482 | Y |
| Steam Generator 12 (22) Pressure PT-478, 479 & 483 | C |
| Steam Generator 11 (21) Level LT-461, 462 & 463 | * |
| Steam Generator 12 (22) Level LT-471, 742 & 473 | * |
| **Boric Acid Tank 11 (12) Level LT-106, 172 & 190 *** | * |
| **Boric Acid Tank 121 Level LT-102, 171 & 189 *** | * |
| Steam Generator 11 (21) Steam Flow FT-464 & 465 | * |
| Steam Generator 12 (22) Steam Flow FT-474 & 475 | * |
| RCS Loop A Hot Leg Temperature TE-402A, 404A, 406A & 408A | * |
| RCS Loop A Cold Leg Temperature TE-402B, 406B & 408B | * |
| RCS Loop B Hot Leg Temperature TE-401A, 403A, 405A & 407A | * |
| RCS Loop B Cold Leg Temperature TE-401B, 403B, 405B & 407B | * |
| Power Range Nuclear Instrumentation NC-41, 42, 43 & 44 | * |
| Pressurizer Pressure PT-429, 430 & 431 | * |
| Pressurizer Level LT-426. 429 & 428 | * |

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| E. VENTILATION DAMPERS (CONTROL ROOM) | |
|---|---|
| 34177 (34176) Outside Air Inlet | * |
| 34145 (34142) Outside Air Inlet to Air Conditioner | * |
| 34144 (34143) Air Conditioner Outlet | * |
| 34180 (34178) Outside Air Inlet to PAC Filter | * |
| 34181 (34179) Recirculation inlet to PAE Filter | * |
| 34183 (34182) PAC Filter Outlet | * |

Notes:

** These items are not required to function immediately, due to a design basis crack, but will be used during subsequent operation to achieve a cold shutdown condition.

*** A fourth level channel will be provided for each boric acid storage tank; however, only one channel will be required for indication to achieve cold shutdown.

* Outside those areas which experience a steam environment for this accident

REQUIRED EQUIPMENT LIST FOR AUXILIARY FEEDWATER STEAM LINE BREAK OR CRACK

UNIT 1
COMPARTMENT LOCATION
FIGURE I.A-18

A. MECHANICAL EQUIPMENT

| | |
|---|---|
| **Safety Injection Pumps 1A, 1B,(2A & 2B) | E * |
| Auxiliary Feedwater Pumps 11, 12,(21 & 22) | TB * |
| Diesel Cooling Water Pumps 12 &(22) | SH * |
| Cooling Water Pump Strainers 11, 12,(21 & 22) | SH * |
| Diesel Generators 11 & 12 With Auxiliaries | *** |
| Control Room Ventilation System 121 & 122 | *** |

B. VALVES

| | VALVE | MCC |
|---|---|---|
| **32079 (32182) SIS Pump Suction From RWST | E * | E * |
| **32080 (32183) SIS Pump Suction From RWST | E * | E * |
| **32081 (32184) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| **32082 (32185) SIS Pump Suction From Boric Acid Tanks | E * | E * |
| 32025 (32030) AFWP 11 (22) Suction From Cooling Water | TB * | TB * |
| 32027 (32026) AFWP 12 (21) Suction From Cooling Water | TB | TB * |
| 32264 (32265) AFWP 11 (22) Steam Supply | TB | TB * |
| 31059 (31060) AFWP 11 (22) Steam Supply Throttle Valve | TB | TB * |
| 32023 (32038) Steam Gen. 11 (21) Feedwater Isolation | X | E (X) * |
| 32024 (32029) Steam Gen. 12 (22) Feedwater Isolation | B | E (X) * |
| 31098 (31116) Main Stream Isolation Valve 11 (21) | Y | |
| 31099 (31117) Main Steam Isolation Valve 12 (22) | B | |
| **31084 (31102) Atmospheric Relief Valve 11 (21) | Y | |
| **31089 (31107) Atmospheric Relief Valve 12 (22) | A | |
| **31231 (31233) Pressurizer Relief Valve | * | |
| **31232 (31234) Pressurizer Relief Valve | * | |

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C. ELECTRICAL COMPONENTS

The controls, power and protection for the mechanical equipment previously listed as well as:

| | |
|---|---|
| Reactor Trip Breakers | B * |
| Batteries 11, 12,(21 & 22) | TB * |
| 480 Volt Buses 110, 120,(210 & 220) | B * |
| 4160 Volt Buses 15, 16,(25 & 26) | TB * |

( ) Unit 2
TB - Turbine Bldg.
SH - Screen House
(X) - RELOCATED

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| D. INSTRUMENTATION | Location |
|---|---|
| Steam Generator 11 (21) Pressure PT-468, 469 & 482 | Y |
| Steam Generator 12 (22) Pressure PT-478, 479 & 483 | C |
| Steam Generator 11 (21) Level LT-461, 462 & 463 | * |
| Steam Generator 12 (22) Level LT-471, 742 & 473 | * |
| **Boric Acid Tank 11 (12) Level LT-106, 172 & 190 *** | * |
| **Boric Acid Tank 121 Level LT-102, 171 & 189 *** | * |
| Steam Generator 11 (21) Steam Flow FT-464 & 465 | * |
| Steam Generator 12 (22) Steam Flow FT-474 & 475 | * |
| RCS Loop A Hot Leg Temperature TE-402A, 404A, 406A & 408A | * |
| RCS Loop A Cold Leg Temperature TE-402B, 406B & 408B | * |
| RCS Loop B Hot Leg Temperature TE-401A, 403A, 405A & 407A | * |
| RCS Loop B Cold Leg Temperature TE-401B, 403B, 405B & 407B | * |
| Power Range Nuclear Instrumentation NC-41, 42, 43 & 44 | * |
| Pressurizer Pressure PT-429, 430 & 431 | * |
| Pressurizer Level LT-426. 429 & 428 | * |

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| E. VENTILATION DAMPERS (CONTROL ROOM) | |
|---|---|
| 34177 (34176) Outside Air Inlet | * |
| 34145 (34142) Outside Air Inlet to Air Conditioner | * |
| 34144 (34143) Air Conditioner Outlet | * |
| 34180 (34178) Outside Air Inlet to PAC Filter | * |
| 34181 (34179) Recirculation inlet to PAE Filter | * |
| 34183 (34182) PAC Filter Outlet | * |

Notes:

** These items are not required to function immediately, due to a design basis crack, but will be used during subsequent operation to achieve a cold shutdown condition.

*** A fourth level channel will be provided for each boric acid storage tank; however, only one channel will be required for indication to achieve cold shutdown.

* Outside those areas which experience a steam environment for this accident