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Subject: **Partial Response to a Portion of NRC RAI Letter No. 369 Related to ESBWR Design Certification Application - DCD Tier 2 Section 3.6 – Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping; RAI Number 3.6-6 S04 - Parts A & C**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) partial response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 369 sent by NRC letter dated September 16, 2009 (Reference 1). RAI Number 3.6-6 S04 parts A and C are addressed in Enclosure 1. Enclosure 2 contains the DCD changes as a result of GEH's response to this RAI.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

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Vice President, ESBWR Licensing

Reference:

1. MFN 09-601 Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No. 369 Related to ESBWR Design Certification* dated September 16, 2009

Enclosure:

1. Partial Response to a Portion of NRC Request for Additional Information Letter No. 369 Related to ESBWR Design Certification Application - DCD Tier 2 Section 3.6 – Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping; RAI Number 3.6-6 S04 Parts A and C

2. Partial Response to a Portion of NRC Request for Additional Information Letter No. 369 Related to ESBWR Design Certification Application - DCD Markups for RAI Number 3.6-6 S04 Parts A and C

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	HA Upton	GEH/San Jose (with enclosures)
	eDRF Section	0000-0108-2326 (RAI 3.6-6 S04 Parts A & C)

Enclosure 1

MFN 09-666

Partial Response to Portion of NRC Request for

Additional Information Letter No. 396

Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.6

Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping

RAI Number 3.6-6 S04 Parts A and C

NRC RAI 3.6-6 S04

A) Related to RAI 3.6-6 S03 Part (a):

(1) In its RAI response, GEH stated that for high energy line breaks, it will conduct a thermal hydraulic analysis using the RELAP5 code to compute the mass flow rate and pipe reaction force time history through the break, along with the fluid conditions at the break. Using the mass flow rate and fluid conditions computed with RELAP5, and considering a worst-case displaced pipe configuration (aligned to maximize jet impact on the target structure), GEH will conduct CFD analyses using CFX or FLUENT to compute the time history of the jet loads on the target. The CFD analysis will consider fluid compressibility, and capture the flow effects associated with the jet unsteadiness, nonlinearity, feedback amplification, and jet reflections. In addition, GEH will use ANSYS finite element software to model the target structure, and use the jet load time history computed from steps 1 and 2 as input to the ANSYS analysis. Should the target have any resonances near the dominant frequencies of the jet loading, the resonant amplification and increased structural stresses will be captured in the analysis. The staff finds GEH's clarified approach for modeling jet impingement loads from high energy line breaks acceptable. However, GEH is requested to explain how they will account for uncertainty in the resonance frequencies of the target finite element structural model. As an example, in other dynamic structural modeling approaches used by GEH for ESBWR design (such as those associated with the steam dryer), the loading time histories are stretched or compressed in 2.5 percent increments spanning a +-10 percent uncertainty before they are applied to the structural FE model, ensuring that the worst-case structural response is computed and used to assess structural integrity.

(2) GEH stated that RELAP5 will be used to compute mass flow rates and pipe reaction forces at break locations, along with fluid conditions at the break to be used as inputs to unsteady CFD analyses. However, in GEH Technical Report 0000-0105-2955-R3, GEH uses TRACG to perform these calculations for their example problem of a MSL line break. GEH is requested to clarify/ amend their approach in the DCD to allow for using either RELAP5 or TRACG or some other suitable code that have been previously accepted by the staff.

B) Related to RAI 3.6-6 S03 Part (b): In its response to the RAI, GEH provided a Technical Report 0000-0105-2955-R3, which describes the modeling procedure they plan to apply to ESBWR high energy line breaks unsteady jet calculations. The report includes (1) GEH's general calculation procedure as applied to an unsteady jet configuration measured by Ho and Nosseir (J. Fluid Mech., Vol. 105, pp. 119-142, 1981) and (2) a demonstration of how GEH plan to use this procedure to model unsteady jets from high energy line breaks in ESBWR design calculations. The staff reviewed the information included in this technical report and found that while GEH's procedures are a significant improvement over the previous approach using ANS 58.2, they still have not been sufficiently proven to be conservative methods for computing unsteady resonant jet loads. GEH is requested to address the following staff's concerns.

(1) The current Ho and Nosseir simulations do not demonstrate the key behavior of unsteady jets with strong feedback phenomena. Specifically, the GEH simulations show that the unsteady loads decrease when feedback occurs (Mach number of 0.9) instead of increasing. GEH is requested to further analyze the Ho and Nosseir problem to establish CFD solutions which demonstrate realistic physical behavior, such as increasing unsteady pressures when jet instabilities occur (such as near a Mach Number of 0.9). GEH is also requested to demonstrate the sensitivity of the CFD solution with respect to critical parameters, such as distance between the jet and impingement surface, jet source boundary conditions (pressure and temperature), external conditions, and any other parameters which have a strong influence on the unsteady jet behavior. In summary, GEH is requested to demonstrate that their procedure is a conservative means of bounding the worst-case unsteady jet loads that may occur in an ESBWR high energy line break event.

(2) GEH is requested to establish that solution from the ESBWR MSL B jet flow demonstration is converged with respect to grid/mesh and time step resolution. A mesh convergence study showing that the strong degree of anisotropy in the existing grid does not influence the results would be useful.

(3) GEH is requested to modify the short formal description in the DCD (referencing GEH Technical Report 0000-0105-2955-R3 for further details) of the general procedure that GEH will use to assess dynamic blowdown forces caused by impinging jets emanating from high energy line breaks (the current description is on pages 3.6-21- 22 of Rev. 6 of the DCD). In particular, GEH is requested to include information such as the bullets on page 4 of GEH Technical Report 0000-0105-2955-R3, and some of the information in Tables 2-7 of that report. GEH is also requested to include guidelines and rules of thumb they will apply to generating meshes and grids, and for running FLUENT. Also, GEH is requested to include a description of the procedure they will apply for assessing convergence of their solutions (such as grid resolution studies), and for assessing the sensitivity of their solutions to uncertainties in problem parameters, such as physical distances between jets and impingement surfaces, jet boundary conditions, and external conditions. Finally, GEH is requested to formally list any bias errors and uncertainties they plan to apply to unsteady loads computed using their procedure.

C) Related to RAI 3.6-6 S03 Part (d):

GEH responded to the RAI in MFN 09-298 Enclosure 1, dated 12 May 2009, and agreed to include tables pertaining to pipe break locations in the DCD, including pipe break data. However, GEH stated that it will not include all the technical data that GEH had previously provided in the responses to RAI 3.6-6 S02 (Tables 1 &2), RAI 3.6-13 S01 (Tables 1 &2), and RAI 3.6-16 S01, (Tables 1&2) since the information contained in these tables has GEH proprietary information. The staff also noted that in its response to RAI 3.6-16 S02, GEH stated that no DCD changes will be made in response to this RAI other than those described in the responses to RAIs 3.6-6 S03 and 3.6-13 S02. Based on its review of the information included in GEH's responses to RAIs 3.6-6, -13 and -16 and their associated tables as well as provided in ESBWR DCD Revision 6, the staff determines that the information pertaining to consideration of jet reflections and analysis procedure that GEH plans to use for each postulated break should be included in Tables 3.6-5 through 7 of the DCD. Therefore, GEH is requested to include the following in additional columns and/or notes in Tables 3.6-5 through 7 of the DCD: (a) whether jet reflections will be considered in the jet impingement analyses and (b) the analysis procedure GEH plans to use for each potential pipe break (CFD and FE as described in GEH's response to RAI 3.6-6 S03 (a) or ANS 58.2).

GEH Response to Items A and C

Response to A(1): Section 3.6.2.3.1 of the DCD will be revised to state that loading time histories that are shifted in 2.5 percent increments spanning a ±10 percent uncertainty are applied to the structural FE model. This approach is consistent with the expected uncertainty in the resonant frequencies of the target structure finite element models and with other dynamic structural model approaches used by GEH (e.g., for the steam dryer model).

Response to A(2): Section 3.6.2.3.1 of the DCD will be revised to state that either RELAP5 or TRACG will be used for the thermal hydraulic analysis.

Response to C: Tables 3.6-5 through 3.6-7 will be revised to indicate the analysis method that will be used for each terminal end break. For each terminal end break for which computational fluid dynamics (CFD) and finite element analyses (FEA) are performed, the methods described in GEH's response to RAI 3.6-6 S03 will be used. For the terminal end breaks for which "hand calculation" methods are used to calculate the magnitude of the jet load, there is no interaction with safety-related components and the methods in ANS 58.2 will be used. Jet reflections will be considered in all analyses performed using CFD and FEA.

DCD Impact

DCD Tier 2, Section 3.6.2.3.1 and Tables 3.6-5, 3.6-6 and 3.6-7 will be revised as noted in the attached markup.

Enclosure 2

MFN 09-666

Partial Response to Portion of NRC Request for

Additional Information Letter No. 396

Related to ESBWR Design Certification Application

DCD Markups for RAI Number 3.6-6 S04 Parts A and C

When the target (pipe) is larger than the area of the jet, the effective target area equals the expanded jet area

$$A_{te} = A_x \qquad (3.6\text{-}5)$$

- For all cases, the jet area (A_x) is assumed to be uniform and the load is uniformly distributed on the impinged target area A_{te}.
- Where applicable, on a case-by-case basis, detailed structural analysis of protective devices for safety-related components necessary to achieve and maintain stable shutdown of the plant is performed due to the jet load impact. The analysis steps involved are as follows:

Step 1: Thermal Hydraulic Analysis By RELAP5 Code. A thermal hydraulic analysis of the pipe break is performed to calculate the mass flow rate and pipe reaction force time history through the break, along with the fluid conditions at the break. RELAP5 or TRACG is used for this analysis. The RELAP5 hydrodynamic model is a one-dimensional transient two-phase model with the capability for modeling non-condensable components in the steam phase and/or a soluble component in the water phase. The calculation scheme is based on the conservation of mass, momentum and energy among the control volumes and junctions for each phase, the state equations and constitutive relations (steam generation, wall heat transfer, etc.).

The hydrodynamic model is based on the use of fluid control volumes and junctions to represent the spatial character of the flow. Velocities are located at the junctions and are associated with mass and energy flow between control volumes. The control system provides the capability to evaluate simultaneous algebraic and ordinary differential equations. The capability is primarily intended to simulate control systems typically used in hydrodynamic systems.

A ruptured (circumferential break) pipe geometry is modeled as the control volumes and the required fluid parameters are provided as the input with the appropriate boundary conditions. A thermal hydraulic transient system analysis as a series of control volumes connected by junctions is carried out. The RELAP5 codeor TRACG solves one-dimensional mass, momentum and energy equations for volumes assumed to contain homogeneous or non-homogeneous (as the case may be) fluid with the vapor and liquid phases in thermodynamic equilibrium.

This analysis results include the mass flow rate time history through the break and the pipe reaction force time history among other desired output.

Step 2: ANSYS Computational Fluid Dynamics Analysis. This program uses CFX, solver version 11.0 or the solver Fluent V6.3 included in ANSYS. Using the mass flow rate derived from the RELAP5thermal hydraulic analysis and considering a worst case pipe displaced configuration (a pipe position that would cause maximum jet impact to the target structure) and defining the target location and its surface geometry in the computational fluid dynamics program as input, the computational fluid dynamics analysis provides results such as the time history of the force on the target. The computational fluid dynamics analysis captures the flow effects associated with the jet unsteadiness, nonlinearity, feedback amplification and jet reflections.

Step 3: ANSYS Finite Element Analysis (FEA) Method. This program is used to model the target structure by FEA method. Using force time history as the input load resulting from the computational fluid dynamics analysis on the target structure, the transient dynamic analysis is performed. This dynamic time history analysis addresses the resonance (if any) with the input forcing function. To account for the uncertainty in the resonance frequencies of the target structure finite element model, input force time histories that are shifted in 2.5% increments spanning a ±10% uncertainty are applied to the structural FEA model, ensuring that the worst-case structural response is computed and used to assess structural integrity.

3.6.2.3.2 Pipe Whip Effects on Safety-Related Components

This subsection provides the criteria and methods used to evaluate the effects of pipe displacements on safety-related structures, systems, and components following a postulated pipe rupture.

Pipe whip (displacement) effects on safety-related structures, systems, and components can be placed in two categories: (1) pipe displacement effects on components (nozzles, valves, tees, etc.) which are in the same piping run that the break occurs in; and (2) pipe whip or controlled displacements onto external components such as building structure, other piping systems, cable trays, conduits, etc.

Pipe Displacement Effects on Components in the Same Piping Run

The criteria for determining the effects of pipe displacements on inline components are as follows:

- Components such as vessel safe ends and valves which are attached to the broken piping system and do not serve a safety function or failure of which would not further escalate the consequences of the accident need not be designed to meet ASME B&PV Code Section III-imposed limits for safety-related components under faulted loading.
- If these components are required for safe shutdown or serve to protect the structural integrity of a safety-related component, limits to meet the ASME B&PV Code requirements for faulted conditions and limits to ensure required operability are met.

  The operability qualification of active pipe mounted components is described in Subsection 3.9.3.
- The methods used to calculate the pipe whip loads on piping components in the same run as the postulated break are described in Subsection 3.6.2.2 under paragraph titled "Pipe Whip Dynamic Response Analyses".

Pipe Displacement Effects on Safety-Related Structures, Systems, and Components

The criteria and methods used to calculate the effects of pipe whip on external components consist of the following:

- The effects on safety-related structures and barriers are evaluated in accordance with the barrier design procedures given in Subsection 3.5.3.

Table 3.6-5

Terminal Pipe End Breaks at RPV Nozzles – High Energy Piping Systems

Terminal Pipe End Breaks for Systems	Location	System Condition	Jet Type	Analysis Method (Note 7)	Rupture Restraint Device Required (Note 6)
30" Main Steam Nozzle (Note 2)	RPV (Four nozzles)	Steam	Compressible, supersonic, turbulent, unsteady and expanding Quality: superheated steam	Jet by CFD Target by FEA	Note 3
12" FW Nozzle	RPV (Six nozzles) (Note 1)	Saturated Water	Compressible (mildly), expanding Quality: subcooled (some flashing can occur)	Enveloped by 12" RWCU analysis	Note 3
12" RWCU Nozzle	RPV (Two nozzles) (Note 1)	Saturated Water	Compressible (mildly), expanding Quality: subcooled (some flashing can occur)	Jet by CFD Target by FEA	Note 3
2" RWCU Drain Nozzle	RPV (Four nozzles located on bottom head of the RPV) (Note 1)	Saturated Water	Compressible, expanding Quality: subcooled (some flashing can occur)	Enveloped by 12" RWCU analysis	Note 4
18" IC Nozzle (Note 2)	RPV (Four nozzles) (Note 1)	Steam	Compressible, supersonic, turbulent, unsteady and expanding Quality: superheated steam	Jet by CFD Target by FEA	Note 3
8" IC Return Nozzle	RPV (Four nozzles) (Note 1)	Saturated Water	Compressible, expanding Quality: subcooled (some flashing can occur)	Enveloped by 12" RWCU analysis	Note 4
6" GDCS Nozzle (Note 2)	RPV (Eight nozzles) (Note 1)	Saturated Water	Compressible, expanding Quality: subcooled (some flashing can occur)	Enveloped by 12" RWCU analysis	Note 4
6" GDCS Equalizing Nozzle (Note 2)	RPV (Four nozzles) (Note 1)	Saturated Water	Compressible, expanding Quality: subcooled (some flashing can occur)	Enveloped by 12" RWCU analysis	Note 4
2" Stand-by Liquid Control Nozzle	RPV (Two nozzles) (Note 1)	Low Temp. Water	Compressible, expanding Quality: subcooled	Enveloped by 12" RWCU analysis	Note 4
2" RPV Level Inst. System (RVLIS) Piping (4 nozzles)	RPV (Four nozzles) (Note 1)	Steam	Compressible, supersonic, expanding Quality: superheated steam	Enveloped by 12" RWCU analysis	Note 4
2" Head Vent Nozzle	RPV (One nozzle) (Note 1)	Steam	Compressible, Supersonic, Expanding Quality: Super heated Steam	Enveloped by 12" RWCU analysis	Note 4
1-1/4" CRD Pipe at CRD Housing	269 Housings (On bottom shell of the RPV)	Low Temp. Water	Compressible, Non-expanding Quality: Subcooled	N/A	Note 5

Notes:
1. The terminal end location is within the Annulus formed by the RPV and Shield wall.
2. The nozzle has Venturi.
3. Rupture restraint device is required.

4. Rupture restraint function can be achieved by stiff pipe support structural hardware.
5. Rupture restraint device is not required.
6. The use of pipe restraints is subject to the final results of the high energy line break evaluations.
7. The analysis methods listed are used for forward flow cases from the reactor vessel and for reverse flow cases. CFD/FEA analyses include consideration of jet reflections.

Table 3.6-6

Terminal Pipe End Breaks Outside Containment – High Energy Piping Systems

Terminal Pipe End Breaks for Systems	Pipe Break Locations	Building	System Condition	Jet Type	Analysis Method (Note 5)	Rupture Restraint Device Required (Note 4)
30" Main Steam Pipe	At header near Turbine Stop Valve	Turbine Building	Enveloped by 12" RWCU analysis Steam	Compressible, supersonic, expanding, turbulent, and unsteady Quality: superheated steam	Enveloped by 30" Main Steam Nozzle CFD analysis (Table 3.6-5)	Note 2
24" FW Pipe	At FW Heater nozzles Number of heaters = 6 (all in concrete wall enclosures)	Turbine Building	Saturated Water	Compressible, expanding Quality: subcooled	Jet by CFD Target by FEA	Note 2
6" & 8" RWCU Piping	At Regenerative Heat Exchanger (in a room)	Reactor Bldg.	Hot Water (for Regenerative Heat Exchanger inlet) Low Temp. Water (for Regenerative Heat Exchanger inlet)	Compressible, expanding (for Regenerative Heat Exchanger inlet), non-expanding for outlet (for Regenerative Heat Exchanger inlet) Quality: subcooled	Scale load based on 12" RWCU Nozzle CFD analysis (Table 3.6-5)	Note 2
12" RWCU Piping	At Non- Regenerative Heat Exchanger (in a room)	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	Results from 12" RWCU Nozzle CFD analysis (Table 3.6-5) are used	Note 2
8" and 12" RWCU Pump nozzles	RWCU pumps inlet (in a room)	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	Results from 12" RWCU Nozzle CFD analysis (Table 3.6-5) are used	Note 1
8" and 12" RWCU Pump	RWCU pumps outlet (in a room)	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	Results from 12" RWCU Nozzle CFD analysis (Table 3.6-5) are used	Note 1
6" RWCU piping	RWCU Demineralizer tank inlet & outlet	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	Scale load based on 12" RWCU Nozzle CFD analysis (Table 3.6-5) (Note 6)	Note 1
8" IC Piping with ≈ 3"Dia. Venturi	At Inlet of Isolation Condenser in IC/PCCS Pool submerged in the water	Reactor Bldg.	Hot Water	Heat Exchanger nozzles submerged in the pool (jetting will not occur)	None required	Note 3

Table 3.6-6

Terminal Pipe End Breaks Outside Containment – High Energy Piping Systems

Terminal Pipe End Breaks for Systems	Pipe Break Locations	Building	System Condition	Jet Type	Analysis Method (Note 5)	Rupture Restraint Device Required (Note 4)
4" IC Piping	At Outlet of Isolation Condenser in IC/PCCS Pool submerged in the water	Reactor Bldg.	Hot Water	Heat Exchanger nozzles submerged in the pool (jetting will not occur)	None required	Note 3
3" Stand-by Liquid Control Piping	At SLC Tank Outlet (in a room)	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	Hand Calculation using DLF of 2.0 for loads (Note 6)	Note 1
1-1/4" CRD Piping (269 Lines)	At HCU (Hydraulic Control Units)	Reactor Bldg.	Low Temp. Water	Compressible, non-expanding Quality: subcooled	N/A (see Section 3.6.2.1.3)	Note 3

Notes:
1. This break is located in a separate room & has no other safety-related components. The pipe whip and jet interactions are limited within its system and components. The need for pipe rupture device is determined during the detailed design phase.
2. Rupture restraint device is required.
3. Rupture restraint device is not required.
4. The use of pipe restraints is subject to the final results of the high energy line break evaluations.
5. Unless otherwise indicated, the analysis methods listed are used for forward flow cases from the reactor vessel; reverse flow cases are not performed. CFD/FEA analyses include consideration of jet reflections.
6. The reverse flow case is also evaluated for these pipe end breaks, using the same analysis method listed for the forward flow case.

Table 3.6-7
Terminal End Breaks at Containment Penetrations
(Inside and Outside the Drywell)

Penetration Number	Description	Pipe Dia, mm (in) (Note 6)	System Condition	Jet Type	Analysis Method (Note 8)	Rupture Restraint Device Required (Note 5 & Note 7)
B21-MPEN-0001 through 4	Main Steam Line A through D	750 (30)	Steam	Same as in Tables 3.6-5 and 3.6-6	Results from 30" Main Steam Nozzle (Table 3.6-5) are used; Target by FEA	Note 1
B21-MPEN-0006 & 7	Feedwater Line A & B	550 (22)	~~Steam~~Saturated Water	Same as in Tables 3.6-5 and 3.6-6	Jet by CFD Target by FEA	Note 1
B21-MPEN-0005	Main Steam Drain Header	100 (4)	Steam/Hot Water (*)	Compressible, supersonic, turbulent, unsteady and expanding Quality: superheated steam	Hand Calculation using DLF of 2.0 for loads; Target by hand calculation	Note 1
B32-MPEN-0001 through 4	IC Train A, B, C & D Steam Supply Line	350 (14)	Steam	Compressible, supersonic, turbulent, unsteady and expanding Quality: superheated steam	Results from 18" IC Nozzle (Table 3.6-5) are used; Target by FEA	Note 2
B32-MPEN-0005 through 8	IC Train A, B, C & D Condensate Return	200 (8)	Hot water	Compressible, expanding Quality: subcooled (some flashing can occur)	Scale load based on 12" RWCU Nozzle CFD analysis (Table 3.6-5); Target by FEA	Note 3
C12-MPEN-0001 through 12	FMCRD: Hydraulic Lines	32 (1.25)	Low Temp. Water	Compressible & non-expanding Quality: Sub-cooled	N/A (see Section 3.6.2.1.3)	Note 4
C41-MPEN-0001 & 2	SLC (Train A & B)	80 (3)	Low Temp. Water	- Compressible, Expanding Quality: Sub-cooled (inside Cont.) - Compressible, non-Expanding Quality: Low temp water (outside)	Hand Calculation using DLF of 2.0 for loads; Target by hand calculation	Note 3
G31-MPEN-0001 & 2	RWCU	300 (12)	Hot water	Compressible (mildly) Expanding Quality: Subcooled (Some flashing can occur)	Results from 12" RWCU Nozzle CFD analysis (Table 3.6-5) are used; Target by FEA	Note 1

Penetration Number	Description	Pipe Dia, mm (in) (Note 6)	System Condition	Jet Type	Analysis Method (Note 8)	Rupture Restraint Device Required (Note 5 & Note 7)
G31-MPEN-0003 & 4	RPV Bottom Drain Line	150 (6)	Hot Water	Compressible, Expanding Quality: sub-cooled (Some flashing can occur)	Scale load based on 12" RWCU Nozzle CFD analysis (Table 3.6-5); Target by FEA	Note 1

Notes:

1. Rupture restraint device is required on piping (inside and outside the penetration) near isolation valve.
2. Rupture restraint device is required inside the drywell side of the penetration only. This line penetrates the upper drywell through penetration into the IC/PCCS pool.
3. Rupture restraint function can be achieved by stiff pipe support structural hardware.
4. Rupture restraint device is not required.
5. See Figure 3.6-3 (Typical) for pipe break location.
6. Pipe diameter may be reduced at the containment penetration.
7. The use of pipe restraints is subject to the final results of the high energy pipe break evaluations.
8. The analysis methods listed are used for forward flow cases from the reactor vessel and for reverse flow cases. CFD/FEA analyses include consideration of jet reflections.

(*) – System is functional during plant startup only.

Legend:
B21 – System identification
MPEN-0001 – Mechanical Penetration 0001.
CFD – Computational fluid dynamics
FEA – Finite element analysis
DLF – Dynamic load factor