Exelon Generation®

10 CFR 50.90

JAFP-19-0089

September 12, 2019

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

James A. FitzPatrick Nuclear Power Plant
Renewed Facility Operating License No. DPR-59
NRC Docket No. 50-333

Subject: License Amendment Request – Proposed Changes to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

Pursuant to 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (Exelon) proposes changes to the Technical Specifications (TS), Appendix A, of Renewed Facility Operating License No. DPR-59 for James A. FitzPatrick Nuclear Power Plant (JAF).

The proposed changes delete TS Limiting Condition for Operation (LCO) 3.6.2.4, Drywell-to-Suppression Chamber Differential Pressure, associated Actions and Surveillance Requirements; revise the upper level in LCO 3.6.2.2, Suppression Pool Water Level from 14 ft to 14.25 ft; and revise the Allowable Value for Table 3.3.5.1-1, Emergency Core Cooling System Instrumentation Function 3.e. Suppression Pool Water Level – High from 14.5 ft to 14.75 ft.

A pre-submittal meeting was conducted on June 18, 2019. A summary of the meeting is documented in ADAMS Accession No.: ML1917A004. The recommendations from that meeting have been incorporated into this submittal.

The proposed changes have been reviewed by the JAF Plant Operations Review Committee in accordance with the requirements of the Exelon Quality Assurance Program.

Attachment 1 provides the Evaluation of Proposed Changes. Attachment 2 provides the Proposed TS Marked-Up Page. Attachment 3 provides the Proposed Technical

Specifications Bases Marked-Up Page for information only. Attachment 4 provides the proposed markup of the UFSAR for information only as requested during the pre-submittal meeting on June 18, 2019. Attachment 5 provides relevant sections of the current Tech Spec Bases which are being provided to address concerns raised during the pre-submittal meeting as well. Attachment 6 provides the Imperia Technical report supporting this submittal.

Exelon requests approval of the proposed amendment by August 31, 2020. Once approved, the amendment shall be implemented within 120 days.

This amendment request contains no regulatory commitments.

Exelon has concluded that the proposed change presents no significant hazards consideration under the standards set forth in 10 CFR 50.92.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), Exelon is transmitting a copy of this application and its attachments to the designated State Officials.

Should you have any questions concerning this submittal, please contact Christian Williams at (610) 765-5729.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 12th day of September 2019.

Respectfully,

David T. Gudger for

James Barstow
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachments:

1) Evaluation of Proposed Changes
2) Proposed Technical Specification Marked-Up Pages
3) Proposed Technical Specification Bases Marked-Up Pages
4) Proposed UFSAR Marked-Up Pages
5) Instrumentation Technical Specification Bases Excerpt
6) Imperia Technical Report, "13-0541-TR-002"

cc:	USNRC Region I, Regional Administrator	w/attachments
	USNRC Senior Resident Inspector, JAF	w/attachments
	USNRC Project Manager, JAF	w/attachments
	A. L. Peterson, NYSERDA	w/attachments

ATTACHMENT 1

License Amendment Request

James A. FitzPatrick Nuclear Power Plant

Docket No. 50-333

EVALUATION OF PROPOSED CHANGES

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

1.0 SUMMARY DESCRIPTION

2.0 DETAILED DESCRIPTION

3.0 TECHNICAL EVALUATION

4.0 REGULATORY EVALUATION

- 4.1 Applicable Regulatory Requirements/Criteria
- 4.2 Precedent
- 4.3 No Significant Hazards Consideration
- 4.4 Conclusions

5.0 ENVIRONMENTAL CONSIDERATION

6.0 REFERENCES

1.0 SUMMARY DESCRIPTION

Pursuant to 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (Exelon) proposes changes to the Technical Specifications (TS), Appendix A, of Renewed Facility Operating License No. DPR-59 for James A. FitzPatrick Nuclear Power Plant (JAF).

The proposed changes delete TS Limiting Condition for Operation (LCO) 3.6.2.4, Drywell-to-Suppression Chamber Differential Pressure, associated Actions and Surveillance Requirements; revise the upper level in LCO 3.6.2.2, Suppression Pool Water Level from 14 ft to 14.25 ft; and revise the Allowable Value for Table 3.3.5.1-1, Emergency Core Cooling System Instrumentation Function 3.e. Suppression Pool Water Level – High from 14.5 ft to 14.75 ft.

2.0 DETAILED DESCRIPTION

The proposed changes address issues related to maintenance of Primary Containment parameters within the limitations of the current LCO 3.6.2.4 (≥ 1.7 psid, drywell above wetwell), LCO 3.6.1.4 (drywell pressure ≤ 1.95 psig), and LCO 3.6.1.6 (Reactor Building-to-Suppression Chamber Vacuum Breakers that actuate at ≤ 0.5 psid, Reactor Building above wetwell, Surveillance Requirement (SR) 3.6.1.6.4). Taken together, these LCOs establish tight constraints on allowable drywell and wetwell pressure.

Drywell and wetwell pressure are taken as gauge measurements with the reference volume being the Reactor Building. In accordance with LCO 3.6.4.1, Secondary Containment, SR 3.6.4.1.1, the Secondary Containment is maintained at ≥ 0.25 inch of vacuum gauge with reference to the outside atmosphere. In practice this means that the Reactor Building (Secondary Containment) pressure changes as barometric pressure changes. Pressure within Primary Containment is essentially fixed and set by the masses of non-condensable gas in the drywell and wetwell airspace and their respective temperatures (which varies only slowly over time). The net effect of this is that nitrogen must be added or removed from the drywell and wetwell to compensate for changes in barometric pressure. Either of these actions require opening Primary Containment Isolation Valves (PCIVs). Removing the requirement to maintain the drywell pressure 1.7 psid above wetwell pressure will permit use of a wider pressure control envelope that will significantly reduce the need to add or remove nitrogen from containment to compensate for changes in barometric pressure.

Proposed Deletion of LCO 3.6.2.4:

LCO 3.6.2.4 Drywell-to-Suppression Chamber Differential Pressure, its associated actions and surveillance requirements will be deleted in its entirety.

The purpose of the proposed change is to minimize the number of PCIV manipulations required to compensate for changes in barometric pressure with the reactor at power.

Proposed Revision to LCO 3.6.2.2:

The upper value of the range in which suppression pool water level must be maintained will be raised from 14 ft to 14.25 ft.

The purpose of the proposed change is to provide increased margin for changes in suppression pool water level associated with changes in drywell to wetwell differential pressure, and to accommodate pool level changes as a result of operations such as High Pressure Coolant Injection or Reactor Core Isolation Cooling System testing that add water to the pool through their turbine exhaust flows.

Proposed Revision to Table 3.3.5.1-1:

The Allowable Value for Table 3.3.5.1-1 Function 3.e., Suppression Pool Water Level – High will be raised from 14.5 ft to 14.75 ft.

The purpose of the proposed change is to maintain a consistent margin between the Allowable Value in Table 3.3.5.1-1 and the upper limit of LCO 3.6.2.2.

Proposed Bases Revision:

The JAF TS Bases for Containment Systems and Emergency Core Cooling System Instrumentation are revised consistent with the proposed changes to LCO 3.6.2.4, LCO 3.6.2.2, and Table 3.3.5.1-1 respectively.

3.0 TECHNICAL EVALUATION

The current Technical Specification requirements for maintenance of a pressure differential between the drywell and torus and the magnitude of the suppression pool water level band were established in response to testing done by General Electric in the early 1970's. These tests identified previously unknown hydrodynamic loads in the torus that would result from a large pipe break in the drywell. The Mark I Torus Program began in 1974 to study these loads and the stresses induced on structures and piping. The Mark I Short Term Program (STP) addressed the initial period of the large break accident, where rapidly expanding steam in the drywell forces air (nitrogen) and steam into the wetwell causing high downward pressure on the torus shell, followed by rapid upward motion of the pool water. This initial break load became known as the pool swell load. Early testing showed that the pool swell load could be mitigated by pressurizing the drywell, which reduced the water volume inside the downcomers, lowering the back pressure resisting the air/steam discharge.

In conjunction with the STP, JAF submitted its Plant Unique Analysis (PUA) which confirmed the structural and functional capability of the torus and attached piping to withstand the newly-identified hydrodynamic loading conditions. Subsequent to submittal of its PUA, license amendment No. 036 issued TS changes to assure that the allowable range of drywell-wetwell differential pressure and torus water level during facility operation would be in accordance with the values utilized in the PUA. These changes included a ≥ 1.7 psi delta P and changing the Torus water level band from ≥ 13.75 ft and ≤ 14.25 ft to ≥ 13.88 ft and ≤ 14.0 ft. As described below, primary containment structural response to accidents has been re-analyzed and previous restrictions imposed to limit hydrodynamic loading are no longer required.

3.1 Containment short term response

Technical Report 005N1724, developed by GE-Hitachi, evaluates the short-term containment pressure and temperature response to the limiting Design Basis Loss of Coolant Accident for zero differential pressure and a suppression pool high water level of 14.25 ft. This report uses the same NRC approved evaluation method previously used in the current analysis of record (NEDC-33087P, Rev. 001). Containment peak pressure and temperature have been recalculated at both 100% and 105% core flow and are compared to the current analysis of record in table 1 below. There is a slight increase in both peak pressure and temperature as compared to the current analysis of record, however, the new values remain bounded by the Drywell design values (56 psig or 70.7 psia and 309 ^{0}F). Note the maximum suppression pool temperature will remain bounded as this is based on the minimum suppression pool water volume and occurs later in the event than is considered in the short term response.

Table 1 – Peak Drywell Pressure and Temperature

	Peak Values 100% of Rated Core Flow	Peak Values 105% of Rated Core Flow	NEDC-33087P Results
Peak Drywell Pressure (psia)	57.7	57.8	54.5
Peak Drywell Temperature (^{0}F)	289.5	289.6	285.9

Containment hydrodynamic loads were also evaluated in 005N1724 and provided for the structural evaluations of 13-0541-TR-002 described below.

3.2 Structural evaluation

Technical Report “13-0541-TR-002” (Attachment 6), developed by Imperia Engineering Partners, demonstrates the structural adequacy of the torus structural elements and Torus Attached Piping (TAP) for the new proposed normal operating parameters. The methodology of this report uses the current Mark I Containment Program analysis and applies appropriate factors to account for 0 psid delta P, the torus water level increase and all other applicable plant changes since the end of the Mark 1 program. A detailed explanation of inputs, methodologies, calculations and conclusions can be found in 13-0541-TR-002. In summary, the report’s conclusion is that all applicable Structural Elements and TAP continue to meet Code requirements with adequate margin under the new normal operating parameters.

3.3 Environmental Qualification (EQ)

The proposed TS changes were evaluated for potential impacts to the Environmental Qualification Service Conditions. It was determined that the normal, abnormal and accident service conditions are not impacted or remain bounded as detailed below.

The normal and abnormal temperatures will not be impacted by the proposed TS changes as these design values are based on minimum Torus water level. The normal and abnormal pressures will remain well below the accident pressures and therefore will not affect qualification. The EQ accident pressure envelope continues to bound the peak short term accident pressure given in section 3.1 above. The EQ accident temperature envelope is established by Main Steam Line breaks and is not significantly affected by the change in normal operating parameters associated with this change. The normal, abnormal and accident relative humidity is already assumed to be 100% in the suppression pool when the plant is operating and therefore will not be impacted. The normal, abnormal and accident radiation will not be impacted as discussed in section 3.4 below.

3.4 Radiological dose analyses

The current Control Room, EQ and Offsite Dose analyses for JAF are based on TID-14844 methodology. These analyses use the minimum initial suppression pool water level (13.88 ft) to determine suppression pool water volume and associated suppression pool free air volume as design basis inputs. The proposed changes of this LAR will have no impact on the minimum initial suppression pool water level and therefore no impact on the current radiological dose analyses.

3.5 Net Positive Suction Head (NPSH)

The analysis for Emergency Core Cooling (ECCS) and Reactor Core Isolation (RCIC) System pump suppression pool NPSH uses the minimum initial suppression pool water level (13.88 ft). It is conservative to use the minimum initial suppression pool water level as the available NPSH for these pumps decreases with lowering suppression pool water level. The proposed changes of this LAR will have no impact on the minimum initial suppression pool water level and therefore no impact on the current NPSH analyses.

3.6 HPCI - Suppression Chamber High Water Level Allowable Value Change

The HPCI, suppression pool water level – high Allowable Value in Technical Specification Table 3.3.5.1-1 is currently "≤ 14.5 ft". This value is established in JAF-ICD-HPCI-03236 to ensure that the suppression pool is not filled beyond its capacity during a LOCA. An allowable margin of 6 inches above the normal high water level is an acceptable value as it would be a negligible increase of water, and associated decrease of free air volume, in comparison to the total volumes in the torus. When this value is reached while fulfilling the coolant injection function, the HPCI pump suction should be taken from the suppression pool instead of the Condensate Storage Tanks (CSTs). Up until the issuance of the Improved Technical Specifications (ITS) this value was always "≤ 6 in. above normal level" and therefore would have corresponded to ≤ 14.75 ft when the torus maximum water level was 14.25 ft. The proposed change will increase the associated Technical Specification Allowable Value proportionally with the increase in maximum torus water level. The 6" margin above the normal high water level is not being changed. This will allow for the suppression pool to remain under its capacity and will not result in the inadvertent actuation of the HPCI pump suction transfer from the CST to torus during normal operation.

The Allowable Value provided in Technical Specification Table 3.3.5.1-1 Function 3.e is based on JAF-CALC-HPCI-00324. This setpoint and uncertainty calculation utilizes the methodology described within the JAF Technical Specification Bases as reviewed by the NRC during the JAF conversion to Improved Technical Specifications. A summary of the setpoint calculation methodology is provided in the attached excerpt from TS Bases Revision 40 section B.3.3.5.1 (attachment 5). The calculation will be revised in support of this effort and will utilize an Analytical Limit of 14.75 ft for suppression chamber level. Since the Suppression Chamber level switches that perform function will remain the same, the associated instrument loop error and calibration limits (As Found and As Left) will also remain the same.

JAF has not yet adopted Technical Specification Task Force (TSTF) Traveler TSTF-493. Therefore, the applicable notes from the TSTF will not be added to the JAF Technical Specifications.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

The following regulatory requirements have been considered:

Title 10 of the Code of Federal Regulations (10 CFR), Section 50.36, "Technical specifications," in which the Commission established its regulatory requirements related to the contents of the TS. Specifically, 10 CFR 50.36(c)(2)(i) states, in part, "Limiting conditions for operation are the lowest functional capability or performance levels of equipment required for safe operation of the facility." 10 CFR 50.36(c)(2)(ii) states, "A technical specification limiting condition for operation of a nuclear reactor must be established for each item meeting one or more of the following criteria:" 10 CFR 50.36(c)(2)(ii)(B) states, “A process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.” 10 CFR 50.36(c)(2)(ii)(A) states, “Installed instrumentation that is used to detect, and indicate in the control room, a significant abnormal degradation of the reactor coolant pressure boundary.”

The proposed changes to the Primary Containment Isolation and RPV Water Inventory Control Instrumentation Allowable Values do not affect compliance with these regulations.

The applicable 10 CFR Part 50, Appendix A, General Design Criteria (GDC), were considered as follows:

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

The proposed changes maintain restrictions on normal operating parameters sufficient to ensure that the hydrodynamic loads associated with a loss-of-coolant accident are within the structural capacity of Primary Containment systems.

Criterion 13 – Instrumentation and control. Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

The proposed change maintains Suppression Pool water level as a parameter monitored to ensure proper functioning of the Primary Containment System. The revised (and current)

Allowable Levels are chosen to ensure the pool is not overfilled during normal and accident conditions.

Criterion 16 – Containment design. Reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

The Primary Containment will continue to fulfill its function of preventing uncontrolled release of radionuclides when subjected to accident hydrodynamic loads when plant operation is maintained within the revised operating limits of the proposed Technical Specification change.

Criterion 50 – Containment design basis. The reactor containment structure, including access openings, penetrations, and the containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident. This margin shall reflect consideration of (1) the effects of potential energy sources which have not been included in the determination of the peak conditions, such as energy in steam generators and as required by § 50.44 energy from metal-water and other chemical reactions that may result from degradation but not total failure of emergency core cooling functioning, (2) the limited experience and experimental data available for defining accident phenomena and containment responses, and (3) the conservatism of the calculational model and input parameters.

The Primary Containment will continue to function within allowable structural limits with margin following a design basis loss-of-coolant accident when operating with the proposed Technical Specification operating limit changes.

4.2 Precedent

Nine Mile Point Nuclear Station, Unit 1 (NMP1): In January of 1986, NMP1 received approval to eliminate these requirements following completion of similar load evaluations. Like JAF, NMP1 implemented these requirements as part of the Mark 1 Short Term Plan. The basis for implementation as well as the justification for removing are the same for both JAF and NMP1.

4.3 No Significant Hazards Consideration

Exelon has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. **Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?**

   Response: No.

   The proposed changes revise operating limits for containment systems during normal operation that provide the initial conditions at which containment performance to mitigate loss-of-coolant accidents is evaluated. The affected parameters are unrelated to the

Reactor Coolant Pressure Boundary or reactivity control systems and therefore are unrelated to accident initiation or probability of occurrence.

Analysis has demonstrated that the containment will continue to operate within design limits in the event of an accident. Therefore, the consequences of an accident are not significantly affected by the proposed change.

Therefore, the proposed changes do not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The proposed changes do not alter the protection system design, create new failure modes, or change any modes of operation. The proposed changes do not involve a physical alteration of the plant; and no new or different kind of equipment will be installed. Consequently, there are no new initiators that could result in a new or different kind of accident.

Therefore, the proposed changes do not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No.

The proposed changes will eliminate the 1.7 psi differential pressure requirement between the drywell and wetwell, raise the maximum torus water level to 14.25 ft, and raise the HPCI “Suppression Pool Water Level – High” Allowable Value to ≤ 14.75 ft. Technical Report “13-0541-TR-002” evaluated use of these operating parameters and determined that all structural elements continue to meet code requirements with adequate margin. Other design aspects such as Emergency Core Cooling System pump Net Positive Suction Head, Equipment Qualification, and accident radiological dose impacted by the proposed changes were also evaluated and found to have negligible to no impact.

Therefore, the proposed changes do not involve a significant reduction in a margin of safety.

Based on the above, Exelon concludes that the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92(c) and, accordingly, a finding of “no significant hazards consideration” is justified.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

1. 005N1724, “James A. FitzPatrick Nuclear Power Plant Short-Term Containment Analysis for Zero Drywell-to-Wetwell Pressure Differential,” Rev. 0, May 2019
2. JAF-RPT-MISC-04046, “Environmental Qualifications Service Conditions”, Rev. 000, Sep 2002
3. JAF-ICD-HPCI-03236, “Torus High Water Level Analytical Limit”, Rev. 000, Dec 1998
4. JAF-CALC-HPCI-00324, “23LS-91A,B Suppression Chamber Level Switch Trip Setpoint”, Rev. 002, February 1999

ATTACHMENT 2

License Amendment Request

James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

Proposed Technical Specification Marked-Up Page

TS Page

3.3.5.1-10

3.6.2.2-1

3.6.2.4-1

3.6.2.4-2

Table 3.3.5.1-1 (page 3 of 5)
Emergency Core Cooling System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER FUNCTION	CONDITIONS REFERENCED FROM REQUIRED ACTION A.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
2. LPCI System (continued)					
g. Low Pressure Coolant Injection Pump Discharge Flow – Low (Bypass)	1, 2, 3	1 per subsystem	E	SR 3.3.5.1.5 SR 3.3.5.1.6	≥ 1040 gpm and ≤ 1665 gpm
h. Containment Pressure - High	1, 2, 3	4	B	SR 3.3.5.1.3 SR 3.3.5.1.6	≥ 1 psig and ≤ 2.7 psig
3. High Pressure Coolant Injection (HPCI) System					
a. Reactor Vessel Water Level – Low Low (Level 2)	1, 2(c), 3(c)	4	B	SR 3.3.5.1.1 SR 3.3.5.1.2 SR 3.3.5.1.4 SR 3.3.5.1.5 SR 3.3.5.1.6	≥ 126.5 inches
b. Drywell Pressure - High	1, 2(c), 3(c)	4	B	SR 3.3.5.1.1 SR 3.3.5.1.2 SR 3.3.5.1.4 SR 3.3.5.1.5 SR 3.3.5.1.6	≤ 2.7 psig
c. Reactor Vessel Water Level – High (Level 8)	1, 2(c), 3(c)	2	C	SR 3.3.5.1.1 SR 3.3.5.1.2 SR 3.3.5.1.4 SR 3.3.5.1.5 SR 3.3.5.1.6	≤ 222.5 inches
d. Condensate Storage Tank Level - Low	1, 2(c), 3(c)	4	D	SR 3.3.5.1.3 SR 3.3.5.1.6	≥ 59.5 inches
e. Suppression Pool Water Level – High	1, 2(c), 3(c)	2	D	SR 3.3.5.1.3 SR 3.3.5.1.6	≤ ~~14.5~~ 14.75 ft
f. High Pressure Coolant Injection Pump Discharge Flow - Low (Bypass)	1, 2(c), 3(c)	1	E	SR 3.3.5.1.5 SR 3.3.5.1.6	≥ 475 gpm and ≤ 800 gpm
g. High Pressure Coolant Injection Pump Discharge Pressure – High (Bypass)	1, 2(c), 3(c)	1	E	SR 3.3.5.1.3 SR 3.3.5.1.6	≥ 25 psig and ≤ 80 psig

(continued)

(c) With reactor steam dome pressure > 150 psig.

3.6 CONTAINMENT SYSTEMS

14.25 ft.

3.6.2.2 Suppression Pool Water Level

LCO 3.6.2.2 Suppression pool water level shall be ≥ 13.88 ft and ≤ ~~14~~ ft.

---NOTE---
Not required to be met for up to 4 hours during Surveillances that cause suppression pool water level to be outside the limit.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Suppression pool water level not within limits.	A.1	Restore suppression pool water level to within limits.	2 hours
B. Required Action and associated Completion Time not met.	B.1	Be in MODE 3.	12 hours
	<u>AND</u>		
	B.2	Be in MODE 4.	36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.2.2.1	Verify suppression pool water level is within limits.	In accordance with the Surveillance Frequency Control Program

3.6 CONTAINMENT SYSTEMS

3.6.2.4 Drywell-to-Suppression Chamber Differential Pressure

LCO 3.6.2.4 The drywell pressure shall be maintained ≥ 1.7 psi above the pressure of the suppression chamber.

--------------------------NOTE--------------------------

delete entire section

that

APPLIC

a. From 24 hours after THERMAL POWER is > 15% RTP following startup, to

b. 24 hours prior to reducing THERMAL POWER to < 15% RTP prior to the next scheduled reactor shutdown.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Drywell-to-suppression chamber differential pressure not within limit.	A.1	Restore differential pressure to within limit.	8 hours
B. Required Action and associated Completion Time not met.	B.1	Reduce THERMAL POWER to ≤ 15% RTP.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.2.4.1	Verify drywell-to-suppression chamber differential pressure is within limit.	In accordance with the Surveillance Frequency Control Program

delete entire section

ATTACHMENT 3

License Amendment Request

James A. FitzPatrick Nuclear Power Plant

Docket No. 50-333

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

Proposed Technical Specification Bases Marked-Up Page
(for information only)

Bases Page

B 3.6.1.4-1

B 3.6.1.4-2

B 3.6.1.7-2

B 3.6.2.2-1

B 3.6.2.2-2

B 3.6.2.2-3

B 3.6.2.4-1

B 3.6.2.4-2

B 3.6.2.4-3

B 3.6 CONTAINMENT SYSTEMS

B 3.6.1.4 Drywell Pressure

BASES

BACKGROUND

The drywell pressure is limited during normal operations to preserve the initial conditions assumed in the accident analysis for a Design Basis Accident (DBA) or loss of coolant accident (LOCA).

APPLICABLE SAFETY ANALYSES

Primary containment performance is evaluated for the entire spectrum of break sizes for postulated LOCAs (Ref. 1). Among the inputs to the DBA is the initial primary containment internal pressure ~~(Refs. 1, 2 and 3)~~ (Refs. 1, 2, 3 and 4). Analyses assume an initial drywell pressure of 1.95 psig. This limitation ensures that the safety analysis remains valid by maintaining the expected initial conditions and ensures that the peak LOCA drywell internal pressure does not exceed the drywell design pressure of 56 psig.

The maximum calculated drywell pressure occurs during the reactor blowdown phase of the DBA, which assumes an instantaneous recirculation line break. The calculated peak drywell pressure for this limiting event is ~~41.2~~ 43.1 psig (Ref. 4).

Drywell pressure satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii) (Ref. 5).

LCO

In the event of a DBA, with an initial drywell pressure ≤ 1.95 psig, the resultant peak drywell accident pressure will be maintained below the maximum allowable drywell pressure.

APPLICABILITY

In MODES 1, 2, and 3, a DBA could cause a release of radioactive material to primary containment. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations of these MODES. Therefore, maintaining drywell pressure within limits is not required in MODE 4 or 5.

ACTIONS

A.1

With drywell pressure not within the limit of the LCO, drywell pressure must be restored within 1 hour. The Required Action is necessary to return operation to within

(continued)

BASES

ACTIONS

A.1 (continued)

the bounds of the primary containment analysis. The 1 hour Completion Time is consistent with the ACTIONS of LCO 3.6.1.1, "Primary Containment," which requires that primary containment be restored to OPERABLE status within 1 hour.

B.1 and B.2

If drywell pressure cannot be restored to within limit within the required Completion Time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.6.1.4.1

Verifying that drywell pressure is within limit ensures that plant operation remains within the limit assumed in the primary containment analysis. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

REFERENCES

1. UFSAR, Section 14.6.1.3.3.

2. NEDO-24578, Revision 0, Mark I Containment Program Plant Unique Load Definition, James A. FitzPatrick Nuclear Power Plant, March 1979.

3. UFSAR, Section 16.9.3.5.

4 .UFSAR, Section 16.9.3.5.1.3.

5. 10 CFR 50.36(c)(2)(ii).

4. 005N1724, “James A. FitzPatrick Nuclear Power Plant Short-Term Containment Analysis for Zero Drywell-to-Wetwell Pressure Differential,” Rev. 0, May 2019

BASES

BACKGROUND (continued)

drywell pressure. This in turn will result in an increase in the pool swell dynamic loads. The suppression chamber-to-drywell vacuum breakers may limit the height of the waterleg in the vent system during time periods when drywell-to-suppression chamber differential pressure is not positive. ~~required or is not maintained within the limits specified in LCO 3.6.2.4, "Drywell-to-Suppression Chamber Differential Pressure."~~

APPLICABLE SAFETY ANALYSES

Analytical methods and assumptions involving the suppression chamber-to-drywell vacuum breakers are used as part of the accident analyses of the primary containment systems. Suppression chamber-to-drywell and reactor building-to-suppression chamber vacuum breakers are provided as part of the primary containment to limit the negative differential pressure across the drywell and suppression chamber walls that form part of the primary containment boundary.

The safety analyses assume that the suppression chamber-to-drywell vacuum breakers are closed initially and start to open at a differential pressure of 0.5 psid (Refs. 1 and 2). Additionally, 1 of the 5 vacuum breakers is assumed to fail in a closed position (Ref. 1). The results of the analyses show that the design differential pressure is not exceeded even under the worst case accident scenario. The vacuum breaker opening differential pressure setpoint and the requirement that all vacuum breakers be OPERABLE (the additional vacuum breaker is required to meet the single failure criterion) are a result of the requirement placed on the vacuum breakers to limit the vent system waterleg height. The cross sectional areas of the vacuum breakers are sized on the basis of the Bodega Bay pressure suppression system tests. The vacuum breaker capacity selected on this test basis is more than adequate to limit the pressure differential between the suppression chamber and drywell during post-accident drywell cooling operations to a value which is within the suppression system design values (Refs. 3 and 4). Design Basis Accident (DBA) analyses assume the vacuum breakers to be closed initially and to remain closed and leak tight, until the suppression pool is at a positive pressure relative to the drywell.

The suppression chamber-to-drywell vacuum breakers satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii) (Ref. 5).

(continued)

B 3.6 CONTAINMENT SYSTEMS

B 3.6.2.2 Suppression Pool Water Level

BASES

BACKGROUND

The suppression chamber is a toroidal shaped, steel pressure vessel containing a volume of water called the suppression pool. The suppression pool is designed to absorb the energy associated with decay heat and sensible heat released during a reactor blowdown from safety/relief valve (S/RV) discharges or from a Design Basis Accident (DBA). The suppression pool must quench all the steam released through the Mark I Vent System downcomer lines during a loss of coolant accident (LOCA). This is the essential mitigative feature of a pressure suppression containment, which ensures that the peak containment pressure is maintained below the maximum allowable pressure for DBAs (62 psig). The suppression pool must also condense steam from the steam exhaust lines in the turbine driven systems (i.e., High Pressure Coolant Injection (HPCI) System and Reactor Core Isolation Cooling (RCIC) System) and provides the main emergency water supply source for the reactor vessel. The suppression pool volume ranges between approximately 105,900 ft^3 at the low water level limit of 13.88 ft and ~~107,400 ft^3~~ 111,360 ft^3 at the high water level limit of ~~14 ft~~ 14.25 ft.

If the suppression pool water level is too low, an insufficient amount of water would be available to adequately condense the steam from the S/RV quenchers, drywell vents, or HPCI and RCIC turbine exhaust lines. Low suppression pool water level could also result in an inadequate emergency makeup water source to the Emergency Core Cooling System. The lower volume would also absorb less steam energy before heating up excessively. Therefore, a minimum suppression pool water level is specified.

If the suppression pool water level is too high, it could result in excessive clearing loads from S/RV discharges and excessive pool swell loads during a DBA LOCA. Therefore, a maximum pool water level is specified. This LCO specifies an acceptable range to prevent the suppression pool water level from being either too high or too low.

(continued)

BASES (continued)

APPLICABLE SAFETY ANALYSIS

Initial suppression pool water level affects suppression pool temperature response calculations, calculated drywell pressure during vent system downcomer clearing for a DBA, calculated pool swell loads for a DBA LOCA, and calculated loads due to S/RV discharges. Suppression pool water level must be maintained within the limits specified so that the safety analysis of References ~~1 and 2~~ 1, 2 and 4 remain valid.

Suppression pool water level satisfies Criteria 2 and 3 of 10 CFR 50.36(c)(2)(ii) (Ref. 3).

LCO

A limit that suppression pool water level be ≥ 13.88 ft and ~~≤ 14~~ 14.25 ft is required to ensure that the primary containment conditions assumed for the safety analyses are met. Either the high or low water level limits were used in the safety analyses, depending upon which is more conservative for a particular calculation.

The LCO is modified by a note which states that the LCO is not required to be met up to four hours during Surveillances that cause suppression pool water level to be outside of limits. These Surveillances include required OPERABILITY testing of the High Pressure Coolant Injection System, the Reactor Core Isolation Cooling System, the suppression chamber-to-drywell vacuum breakers, the Core Spray System and the Residual Heat Removal System. The 4 hour allowance is adequate to perform the Surveillances and to restore the suppression pool water level to within limits.

APPLICABILITY

In MODES 1, 2, and 3, a DBA would cause significant loads on the primary containment. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations in these MODES. The requirement for maintaining suppression pool water level within limits in MODE 4 or 5 is addressed in LCO 3.5.2, "Reactor Pressure Vessel (RPV) Water Inventory Control."

ACTIONS

A.1

With suppression pool water level outside the limits, the conditions assumed for the safety analyses are not met. If water level is below the minimum level, the pressure suppression function still exists as long as the vent system downcomer lines are covered, HPCI and RCIC

(continued)

BASES

ACTIONS

A.1 (continued)

turbine exhausts are covered, and S/RV quenchers are covered. If suppression pool water level is above the maximum level, protection against overpressurization still exists due to the margin in the peak containment pressure analysis and the capability of the Residual Heat Removal Containment Spray System.

Therefore, continued operation for a limited time is allowed. The 2 hour Completion Time is sufficient to restore suppression pool water level to within limits. Also, it takes into account the low probability of an event requiring the suppression pool water level to be within limits occurring during this interval.

B.1 and B.2

If suppression pool water level cannot be restored to within limits within the required Completion Time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.6.2.2.1

Verification of the suppression pool water level is to ensure that the required limits are satisfied. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

REFERENCES

1. UFSAR, Section 14.6.1.3.3.
2. GE-NE-T23-00737-01, James A. FitzPatrick Nuclear Power Plant Higher RHR Service Water Temperature Analysis, August 1996.
3. 10 CFR 50.36(c)(2)(ii).
4. 005N1724, "James A. FitzPatrick Nuclear Power Plant Short-Term Containment Analysis for Zero Drywell-to-Wetwell Pressure Differential," Rev. 0, May 2019

B 3.6 CONTAINMENT SYSTEMS

B 3.6.2.4 Drywell-to-Suppression Chamber Differential Pressure

BASES

BACKGROUND

The toroidal shaped suppression chamber, which contains the suppression pool, is connected to the drywell (part of the primary containment) by eight drywell vent pipes. The [illegible] eader, [illegible] ession [illegible] ft below [illegible] y [illegible] g a loss [illegible] pressure [illegible] the [illegible] blowdown" phase of the event begins. The length of the waterleg has a significant effect on the resultant primary containment pressures and loads.

delete entire section

APPLICABLE SAFETY ANALYSES

The purpose of maintaining the drywell at a slightly higher pressure with respect to the suppression chamber is to minimize the drywell pressure increase necessary to clear the downcomer pipes to commence condensation of steam in the suppression pool and to minimize the mass of the accelerated downcomer waterleg. This reduces the hydrodynamic loads on the torus during the LOCA blowdown (Ref. 1). The required differential pressure results in a downcomer waterleg of 0.37 ft to 0.49 ft.

Initial drywell-to-suppression chamber differential pressure affects both the dynamic pool loads on the suppression chamber and the peak drywell pressure during downcomer pipe clearing during a Design Basis LOCA. Drywell-to-suppression chamber differential pressure must be maintained within the specified limits so that the safety analysis remains valid.

Drywell-to-suppression chamber differential pressure satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii) (Ref. 2).

LCO

A drywell-to-suppression chamber differential pressure limit of 1.7 psi is required to ensure that the containment conditions assumed in the safety analyses are met. A drywell-to-suppression chamber differential pressure of 1.7 psi corresponds to a downcomer water leg of 0.37 ft to 0.49 ft if suppression pool level is within the limits specified in LCO 3.6.2.2. Failure to maintain the required

(continued)

BASES

LCO (continued)

differential pressure could result in excessive forces on the suppression chamber due to higher water clearing loads from downcomer pipes and higher pressure buildup in the drywell.

The LCO is modified by a Note which states that the LCO is not required to be met up to four hours during Surveillances

delete entire section

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re
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uate
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suppression chamber differential pressure to within limits.

APPLICABILITY

Drywell-to-suppression chamber differential pressure must be controlled when the primary containment is inert. The primary containment must be inert in MODE 1, since this is the condition with the highest probability for an event that could produce hydrogen. It is also the condition with the highest probability of an event that could impose large loads on the primary containment.

Inerting primary containment is an operational problem because it prevents primary containment access without an appropriate breathing apparatus. Therefore, the primary containment is inerted as late as possible in the plant startup and is de-inerted as soon as possible in the plant shutdown. As long as reactor power is < 15% RTP, the probability of an event that generates hydrogen or excessive loads on primary containment occurring within the first 24 hours following a startup or within the last 24 hours prior to a shutdown is low enough that these "windows," with the primary containment not inerted, are also justified. The 24 hour time period is a reasonable amount time to allow plant personnel to perform inerting or de-inerting.

ACTIONS

A.1

If drywell-to-suppression chamber differential pressure is not within the limit, the conditions assumed in the safety analyses are not met and the differential pressure must be restored to within the limit within 8 hours. The 8 hour Completion Time provides sufficient time to restore

(continued)

BASES

ACTIONS

A.1 (continued)

differential pressure to within limit and takes into account the low probability of an event that would create excessive suppression chamber loads occurring during this time period.

delete entire section

12 hour Completion Time is reasonable, based on operating experience, to reduce reactor power from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.6.2.4.1

The drywell-to-suppression chamber differential pressure is regularly monitored to ensure that the required limits are satisfied. The 12 hour Frequency of this SR was developed based on operating experience relative to differential pressure variations during applicable MODES. Furthermore, the 12 hour Frequency is considered adequate in view of other indications available in the control room, including alarms, to alert the operator to an abnormal pressure condition.

REFERENCES

1. UFSAR, Section 5.2.3.3.

2. 10 CFR 50.36(c)(2)(ii).

ATTACHMENT 4

License Amendment Request

James A. FitzPatrick Nuclear Power Plant

Docket No. 50-333

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

UFSAR Mark-up Pages
(for information only)

UFSAR Pages

4.4-5
5.2-6
5.2-15
5.2-17
5.2-23
12.5-6

at a nominal value of 1.7 psig.

event of a small to intermediate size line break concurrent with a HPCI failure and a loss of the pneumatic supply to the accumulators. This provides short term ADS SRV capability. Long term operation of the SRVs is assured with the seismically qualified lines to the accumulators.

The normal pneumatic supply pressure to the accumulators (120 psi) is sufficient to permit at least five ADS SRV actuations with the drywell pressure ~~at normal drywell pressure (1.7 psig).~~ Normal pneumatic supply pressure is also sufficient to permit at least two ADS SRV actuations with the drywell pressure at 70% of drywell design pressure (39.2 psig). This pressure exceeds the analyzed maximum intermediate-break LOCA drywell pressure of 34.5 psig. The accumulator and check valves are capable of storing this supply for at least one hour following a loss of pneumatic supply assuming a leakage of 0.12 scfh. Adequate accumulator capacity is available for five valve actuations assuming that the first and second actuations occur at 70% of drywell design pressure and the three subsequent actuations occur at normal drywell pressure. No Leakage or time delay is assumed in establishing this capability.

In each case, only one ADS valve actuation at 70% of drywell design pressure is required to depressurize the reactor and allow inventory make-up by the low pressure ECCS systems and thus meet the ADS system safety design basis. However for conservatism the short-term ADS pneumatic supply is sized to provide additional actuations. With a low pneumatic supply pressure of 95 psig and a drywell pressure of 70% of the drywell design pressure, the accumulator stores sufficient energy for a single actuation of the ADS SRVs within one hour following loss of pneumatic pressure supply based on an assumed leakage of 0.12 scfh. The ability of the accumulators to provide actuation of the SRVs at 70% of drywell design pressure is acceptable since this pressure is greater than the analyzed maximum drywell pressure for an intermediate size line break LOCA Higher pressures are seen only for short periods during the initial phase of large-break LOCAs.

Long-Term ADS Pneumatic Supply

The pneumatic supply system for the ADS valves provides a reliable, safety-related, seismically qualified, 100-day supply following a design basis accident to enable long-term cooling. The purpose of this capability is to keep the reactor pressure low enough so that the low pressure ECCS systems can be used to maintain the core cooled. This safety-related pneumatic supply is provided from redundant trains of the drywell inerting and purge system to the ADS pneumatic supply header. This long term supply meets the guidance of NUREG 0737 Item II.K.3.28. Refer to section 5.2.3.8 for details of the pneumatic supply arrangement.

The automatic depressurization feature of the Pressure Relief System serves to back up the HPCI System under LOCA conditions. If the HPCI System does not operate and a discharge pressure signal exists at any one of four of the LPCI or either of two core spray pumps, the Reactor Coolant System is depressurized sufficiently to permit the LPCI and Core Spray System to operate to protect the fuel barrier. Depressurization occurs when some of the safety/relief valves are opened automatically to vent steam to the suppression pool. For small line breaks when the HPCI System fails, the Reactor Coolant System is depressurized in sufficient time to allow the Core Spray System or LPCI to cool the core and prevent any fuel cladding melting. For large breaks, the vessel depressurizes rapidly through the break without assistance. The signals that are associated with the automatic depressurization mode of seven of the safety/relief valves are described in the Technical Specifications. Overpressure protection is described in NEDA-24011-P (applicable revision) and results of the analysis are given in the supplemental reload licensing submittal. Further descriptions of the operation of the automatic depressurization feature are found in Section 6.4 and in Section 7.4.

Depressurization of the Reactor Coolant System can be effected manually in the event the main condenser is not available as a heat sink after reactor shutdown. The steam generated by core having a diameter of 6.75 ft. The vent pipes are designed for the same pressure and temperature conditions as the drywell and suppression chamber. Jet deflectors are provided in the drywell at the entrance of each vent pipe to prevent possible damage to the vent pipes from jet forces. As shown in Figure 5.2-1 Sheet 2, the vent pipes are provided with expansion joints which are inserted between the vent insert and the vent pipe to accommodate differential motion between the drywell and pressure suppression chamber. The expansion joints are designed to the same requirements as the drywell and pressure suppression chamber.

The vent pipes are connected to a 4 ft-9 inch diameter vent header in the form of a torus which is contained within the air space of the suppression chamber. Projecting downward from the header are 96 downcomer pipes, 24 inch in diameter and terminating approximately 4 ft below the water surface of the pressure suppression pool (9 feet 7 inches above the bottom of the torus). The vent header has the same temperature and pressure design requirements as the vent pipes. The number and size of the downcomer pipes was selected to conform to the range of parameters examined in the Bodega Bay tests.

delete paragraph

During the course of the Mark I Containment short term program, studies of pool swell phenomena showed that a differential pressure between the drywell and torus would significantly reduce the pool swell loads. The drywell-torus differential pressure reduces the length of the water leg inside the downcomer. In the event of a LOCA, the downcomer clearing and subsequent bubble formation will occur earlier at a lower driving pressure.

The differential pressure is being maintained greate [illegible] delete paragraph si at JAF as a one load mitigation technique to restore the intended margins of safety in the containment design. The additional structural assessments required by NUREG 0661 have been made to demonstrate that the containment can maintain its functional capability when the differential pressure control is out of service. Additional limiting conditions for plant operation included in the Technical Specifications are based on the guidance of NUREG 1433. They provide an adequate basis for application of differential pressure control as an effective long term mitigation technique.

The eight bellows type expansion joints in the vent lines between drywell and torus were designed, fabricated, and nondestructively examined in accordance with the ASME Boiler and Pressure Vessel Code for Nuclear Vessels, Section III, Subsection B, 1968 Edition including the 1968 Summer Addendum, plus Code Cases 1330-1 and 1177-5.

5.2.3.4 <u>Penetrations</u>

Containment penetrations have the following design characteristics:

1. They are capable of withstanding the forces caused by impingement of the fluid from the rupture of the largest local pipe or connection without failure.

The nitrogen dilution, purge and sampling systems are originally provided for normal operating functions. The supply leg of the inerting/purge system (storage tank to containment) is designed as a Class II system beyond the second containment isolation valve. The discharge leg, from containment to the stack utilizes valves 27AOV-113 and 27AOV-114 for drywell exhaust and 27AOV-117 and 27AOV-118 for torus exhaust, and then combine flow paths and exhaust through valve 27MOV-121 (Figure 5.2-9). The discharge leg, from the second containment isolation valve to the safety related valves 27MOV-120, 27MOV-121, and 27AOV-142, is designed as non-safety augmented quality which is seismically supported in accordance with NRC Order EA-13-109. Containment purge is exhausted through the standby gas treatment system. The Standby Gas Treatment System having redundant and seismic Class I equipment is described in Chapter 5. The piping associated with MOV 113 is also Class I. The inerting/purge system does not need to meet the requirements of an engineered safeguard system for the following reasons:

1. Redundancy already exists via the use of two independent supply systems for the CAD system. Failure of the inerting/ purge system would not prevent the CAD system from providing adequate flammability protection following a LOCA.

2. The inerting system ~~nitrogen supply~~ is not redundant.

desired

Containment isolation valves on the containment purge and vent lines may be opened for the following reasons: inerting or de-inerting primary containment; maintaining containment oxygen concentrations within limits; maintaining pressure within the drywell and suppression pool~~; and maintaining the differential pressure between the drywell and suppression pool~~. Table 5.2-4 provides the maximum opening angle of eight containment vent and purge isolation valves (27-AOV-111, 112, 113, 114, 115, 116, 117 and 118) to assure that these valves can close against the dynamic effects of a LOCA.

delete sentence

5.2.3.8.2 <u>Containment Make-up Supply</u>

Makeup nitrogen is supplied to either the drywell or suppression chamber as required to maintain the maximum oxygen concentration of 4 percent volume, as indicated by the oxygen analyzers at both locations. Supply will be from either liquid nitrogen tank, and through either of two ambient vaporizers.

5.2.3.8.3 <u>Containment Atmosphere Dilution</u>

The Containment Atmosphere Dilution (CAD) System is provided for the control of postulated combustible gases following a postulated DBA. The gases, hydrogen and oxygen, are assumed to be generated by radiolysis, coolant entrainment and the zirconium metal water reaction. The generation rates are in accordance with AEC Safety Guide No. 7. The only potential source of post-LOCA oxygen within the containment would be that entrained in the reactor coolant. However, this would be an insignificant amount compared to that produced by radiolysis and need not be considered.

Pneumatic systems penetrating the JAF plant containment use nitrogen as the working fluid, therefore in-leakage from these systems does not affect the containment flammability potential. Since the rate of hydrogen generation

5.2.3.8.4 Nitrogen Supply to Containment Instrumentation

The nitrogen supply to the containment instrumentation system is designed to provide the pneumatic supply requirements of instruments and controls inside the drywell including the long term (100 days) pneumatic supply requirements of the Automatic Depressurization System (ADS) Valves and Accumulators following a LOCA. The system consists of two QA Category SR, Seismic Class I trains. Each train consists of an ambient vaporizer, electric heater, pressure control valve, containment isolation valve, controls and instrumentation (see Figures 5.2-9 and 9.11-1). Each train is capable of being supplied from either Class I Liquid Nitrogen Storage Tank. Each train supplies a ring header inside the drywell. This header and branch lines from this header to drywell instrumentation are QA Category SR, Seismic Class I to ensure the integrity of the system following a seismic event.

Containment isolation valves 27SOV-141 and 27SOV-145 have provision for remote manual operation from the CAD panel in the relay room. Valve position indication (full open to full closed) is provided in the control room mimic display, panel 09-4.

In order to meet the Appendix R requirements for 72 hours operation of the ADS valves in the alternate shutdown mode, containment isolation valve 27SOV-141 is wired to the remote shutdown panel. In the event of a fire in the control room, relay room or cable spreading room, an isolation switch in this panel will enable the operator to remotely de-energize solenoid valves 27SOV-141 and 27AOV-129B simultaneously. On loss of power, both of these valves will be to the open position. Actuation of a second isolation switch on this panel will open valve 27AOV-126B. The opening of valves 27AOV-126B, 27AOV-129B and 27SOV-141 which are powered from an alternate power source will allow uninterruptible nitrogen flow to the ADS valves and accumulators.

A safety-related nitrogen supply line is also provided to the air operated reactor building closed loop cooling water system (RBCLCWS) containment isolation valves (see FSAR Section 9.5-3 and Figure 5.2-9). This ensures the reliable, long term operability of the valves. Safety related nitrogen supplies vacuum breaker isolation valves 27AOV-101A and 27AOV-101B.

5.2.3.8.5 Containment Differential Pressure System

delete entire section

The containment differential pressure system is designed to maintain drywell pressure at least 1.7 psi above torus atmosphere pressure while the reactor is operating, except when initially inerting the containment and testing the drywell to torus vacuum breaker valves.

5.2.3.8.6 System Design

a. The CAD System consists of two Class I liquid nitrogen storage tanks, as shown on Figure 5.2-9. Each tank contains a minimum of three days nitrogen for the CAD System, including that lost by evaporation. The minimum level in the tank only occurs during the time period between initial containment inerting and the scheduled tank refill via liquid nitrogen truck. The three day period was selected to offset any nitrogen delivery problems associated with equipment availability or road conditions. The actual volume of liquid nitrogen stored in each tank is based on the nitrogen requirement for the zero to three day period, with allowance for evaporation and maintaining pressure in the tank.

pressure suppression chamber to aid in reducing drywell pressure following a LOCA. A complete description of this system is found in Section 4.8.6.

5.2.3.13 Primary Containment Leakage Monitoring

The primary containment leakage is continuously monitored for gross leakage during plant operation while it is inerted. This is accomplished by review of the inerting system makeup requirements in the following manner:

delete

1. ~~The containment is pressurized or evacuated to greater than or equal to 1.7 psi differential~~.

2. Over a period of time, leakage from the containment causes a change in pressure.

3. When pressure reaches a prescribed limit, the original pressure is re-established.

4. The gas flow is metered to provide a direct measure of containment leakage over the period since the last charge.

5. An immediate investigation is made if abnormal leakage is noted.

There is no specific instrumentation installed to detect leakage from the drywell. The only result of leakage from the drywell to the suppression pool would be to reduce steam condensation during a LOCA. However, Table 5.2-1 indicates considerable margin between the calculated and design pressure of the suppression pool so that 100 percent steam condensation is not required.

Provisions are made so that integrated containment leakage rate tests may be periodically performed during periods of reactor shutdown.

5.2.3.14 Post-Accident Containment Monitoring

The post-accident containment environment is monitored by temperature sensors and high range gamma detectors located within the containment and oxygen, hydrogen and pressure, and radiation monitoring equipment located external to the containment.

Two environmentally qualified redundant, Resistance Temperature Detectors (RTDs) provide input to separate temperature indicating recorders on the Control Room 09-3 panel. These components provide continuous indication and trending of containment temperatures during post-accident conditions.

Revision of the plant unique analysis (Report #TR-5321-1, TR-5321-2) was included in JAF-RPT-MULTI-03000 to reflect reanalysis of the torus structure and torus attached piping. The changes incorporated new design loads resulting from the installation of larger, high debris capacity ECCS suction strainers in the suppression pool during the 1998 refueling outage.

Refer to figure 5.2-17 for details of the SRV tee quencher and a composite cross section of the torus.

In 2005, an ASME Code repair of the torus shell was installed to correct a flaw associated with the HPCI turbine exhaust. The design of the repair included an allowance for cyclic loading associated with postulated condensation oscillation of the HPCI exhaust flow to the torus.

A sparger assembly was installed on the end of the 24" diameter HPCI steam exhaust piping inside the Torus during the 2006 Refueling to mitigate the HPCI steam blowdown Condensation Oscillation (CO) loads inside the Torus.

JAF Calculation JAF-CALC-06-00048 evaluates stress levels in the Torus shell for the HPCI steam blowdown CO load condition. Teledyne Plant Unique Analysis Report of the Suppression Chamber (TR-5321-1) was updated to include this condition.

Add paragraph:
Technical Report "13-0541-TR-002", developed by Imperia Engineering Partners in 2019, demonstrates the structural adequacy of the torus structural elements and Torus Attached Piping (TAP) for normal operation at a Drywell to Wetwell differential pressure of 0 psid and a suppression pool maximum water level of 14.25 ft. This report uses the current plant unique analysis report (TR-5321-1, TR-5321-2) and applies appropriate factors to account for the 0 psid delta P, the torus water level increase and all other applicable plant changes since the end of the Mark 1 program.

12.5.1.4 Vent Header

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lines ar…
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12.5.2 …

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heater …
Radioa…

The frequency response method is used to analyze this structural system. Seismic loading in the form of response spectra for the operating basis and design basis earthquakes are shown in Figures 2.6-1 and 2.6-2.

To determine the free vibration characteristics for the system, a dynamic model consisting of the spring connected lumped masses is generated. Mass elements are described at each significant floor level. The masses consist of the floors, tributary walls and columns and equipment and piping.

Coordinates are established at the mass elements to permit horizontal motion in two directions (x and z) and rotation about the vertical (y) axis. The coordinates are at the center of mass of each discrete mass. The masses are defined as M_{ix}, M_{iz} and I_i0_y.

where $M_{ix} = M_{iz}$ = the ith mass in the respective x and z directions.

I_i0_y = rotational mass moment of inertia of the ith mass about its axis

i designates the mass point

ATTACHMENT 5

License Amendment Request

James A. FitzPatrick Nuclear Power Plant

Docket No. 50-333

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

Instrumentation TS BASES Supporting Pages
(for information only)

TS BASES Pages

3.3.5.1-8
3.3.5.1-9

BASES (continued)

APPLICABLE SAFETY ANALYSIS, LCO, and APPLICABILITY

The actions of the ECCS are explicitly assumed in the safety analyses of References 1, 2, 3, and 4. The ECCS is initiated to preserve the integrity of the fuel cladding by limiting the post LOCA peak cladding temperature to less than the 10 CFR 50.46 limits.

ECCS instrumentation satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii) (Ref. 5). Certain instrumentation Functions are retained for other reasons and are described below in the individual Functions discussion.

The OPERABILITY of the ECCS instrumentation is dependent upon the OPERABILITY of the individual instrumentation channel Functions specified in Table 3.3.5.1-1. Each Function must have a required number of OPERABLE channels, with their setpoints within the specified Allowable Values, where appropriate. The actual setpoint is calibrated consistent with applicable setpoint methodology assumptions. Table 3.3.5.1-1 is modified by a footnote which is added to show that certain ECCS instrumentation Functions also perform EDG initiation.

Allowable Values are specified for each ECCS Function specified in the table. Nominal trip setpoints are specified in the setpoint calculations. The nominal setpoints are selected to ensure that the setpoints do not exceed the Allowable Value between CHANNEL CALIBRATIONS. Operation with a trip setpoint less conservative than the nominal trip setpoint, but within its Allowable Value, is acceptable. A channel is inoperable if its actual trip setpoint is not within its required Allowable Value. Trip setpoints are those predetermined values of output at which an action should take place. The setpoints are compared to the actual process parameter (e.g., reactor vessel water level), and when the measured output value of the process parameter exceeds the setpoint, the associated device (e.g., trip unit) changes state. The analytic limits are derived from the limiting values of the process parameters obtained from the safety analysis or other appropriate documents. The trip setpoints are derived from the analytical limits and account for all worst case instrumentation uncertainties as appropriate (e.g., drift, process effects, calibration uncertainties, and severe environmental errors (for channels that must function in harsh environments as defined by 10 CFR 50.49)). The trip setpoints derived in this manner provide adequate protection because all expected uncertainties are accounted for. The Allowable Values are then derived from the trip setpoints by accounting for normal effects that would be seen during periodic surveillance or calibration. These effects are instrumentation uncertainties observed during normal operation (e.g.,

(continued)

BASES

APPLICABLE SAFETY ANALYSIS, LCO, and APPLICABILITY (continued)

drift and calibration uncertainties).

In general, the individual Functions are required to be OPERABLE in the MODES or other specified conditions that may require ECCS (or EDG) initiation to mitigate the consequences of a design basis transient or accident. To ensure reliable ECCS and EDG function, a combination of Functions is required to provide primary and secondary initiation signals.

The specific Applicable Safety Analyses, LCO, and Applicability discussions are listed below on a Function by Function basis.

<u>Core Spray and Low Pressure Coolant Injection Systems</u>
<u>1.a, 2.a. Reactor Vessel Water Level — Low Low Low (Level 1)</u>

Low reactor pressure vessel (RPV) water level indicates that the capability to cool the fuel may be threatened. Should RPV water level decrease too far, fuel damage could result. The low pressure ECCS and associated EDGs are initiated at Level 1 to ensure that core spray and flooding functions are available to prevent or minimize fuel damage. The EDGs are initiated from Function 1.a and 2.a. The Reactor Vessel Water Level — Low Low Low (Level 1) is one of the Functions assumed to be OPERABLE and capable of initiating the ECCS during the transients analyzed in Reference 3. In addition, the Reactor Vessel Water Level — Low Low Low (Level 1) Function is directly assumed in the analysis of the recirculation line break (Refs. 1, 2, and 4). The core cooling function of the ECCS, along with the scram action of the Reactor Protection System (RPS), ensures that the fuel peak cladding temperature remains below the limits of 10 CFR 50.46.

Reactor Vessel Water Level — Low Low Low (Level 1) signals are initiated from four level transmitters that sense the difference between the pressure due to a constant column of water (reference leg) and the pressure due to the actual water level (variable leg) in the vessel.

The Reactor Vessel Water Level — Low Low Low (Level 1) Allowable Value is chosen to allow time for the low pressure core flooding systems to activate and provide adequate cooling. The Allowable Value is referenced from a level of water 352.56 inches above the lowest point in the inside bottom of the RPV and also corresponds to the top of a 144 inch fuel column (Ref. 6).

Thus, four channels of the CS and LPCI Reactor Vessel Water Level — Low Low Low (Level 1) Function are only required to be OPERABLE when the ECCS are required to be OPERABLE to ensure that no single instrument failure can preclude ECCS initiation.

(continued)

ATTACHMENT 6

License Amendment Request

James A. FitzPatrick Nuclear Power Plant

Docket No. 50-333

Proposed Change to the Technical Specifications Related to Primary Containment Hydrodynamic Loads

<u>Imperia Technical Report 13-0541-TR-002</u>

Design Analysis Cover Sheet

Design Analysis	**Last Page No.** [6] Page L-1
Analysis No.: [1] 13-0541-TR-002	**Revision:** 0[2] Major ☒ Minor ☐
Title: [3] Mark I Program Support to Eliminate Primary Containment Drywell-to-Wetwell Differential Pressure During Normal Operation	
EC No.: [4] EC 626400	**Revision:** [5] 000

		Component(s): [14]	
Station(s): [7]	James A. FitzPatrick	Various	
Unit No.: [8]	1	Torus	Containment
Discipline: [9]	Mechanical Engineering Technical Report	Suppression Chamber	Torus Attached Piping
Descrip. Code/Keyword: [10]	Mark I, Torus, Drywell, Wetwell, Suppression Chamber, Containment		
Safety/QA Class: [11]	Quality-Related		
System Code: [12]	Various		
Structure: [13]	Primary Containment		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
See Section 7.0 for Reference List			

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ If yes, ATI/AR#: ______

[8]

Description of Revision (list changed pages when all pages of original analysis were not changed): [19]
See Revision Summary in Pages 3-5.
Imperia's revision 0 of this report was never issued by Exelon as a controlled document in passport, therefore Imperia's revision 1 of this report will be officially issued in passport as revision 0.

	Print Name	Sign Name	Date
Preparer: [20]	Raymond M. Pace	[signature]	8/2/19

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

	Print Name	Sign Name	Date
Reviewer: [22]	Silvester Noronha Robert Skwirz	[signatures]	8/2/19

Independent review ☒ Peer review ☐

Review Notes: [23]

(For External Analyses Only)

	Print Name	Sign Name	Date
External Approver: [24]	Raymond M. Pace	[signature]	8/2/19
Exelon Reviewer: [25]	Jason Ritzel	[signature]	8/6/19

Independent 3rd Party Review Reqd? [26] Yes ☐ No ☒

	Print Name	Sign Name	Date
Exelon Approver: [27]	Peter T Latenbach	[signature]	8/6/19

ATTACHMENT 2
Owner's Acceptance Review Checklist for External Design Analyses
Page 1 of 3

Design Analysis No.: 13-0541-TR-002 **Rev:** 1
Contract #: 00610977 **Release #:** 0005

No	Question	Instructions and Guidance	Yes / No / N/A
1	Do assumptions have sufficient documented rationale?	All Assumptions should be stated in clear terms with enough justification to confirm that the assumption is conservative. For example, 1) the exact value of a particular parameter may not be known or that parameter may be known to vary over the range of conditions covered by the Calculation. It is appropriate to represent or bound the parameter with an assumed value. 2) The predicted performance of a specific piece of equipment in lieu of actual test data. It is appropriate to use the documented opinion/position of a recognized expert on that equipment to represent predicted equipment performance. Consideration should also be given as to any qualification testing that may be needed to validate the Assumptions. Ask yourself, would you provide more justification if you were performing this analysis? **If** yes, the rationale is likely incomplete.	☒ Yes ☐ No ☐ N/A
2	Are assumptions compatible with the way the plant is operated and with the licensing basis?	Ensure the documentation for source and rationale for the assumption supports the way the plant is currently or will be operated post change and they are not in conflict with any design parameters. If the Analysis purpose is to establish a new licensing basis, this question can be answered yes, if the assumption supports that new basis.	☒ Yes ☐ No ☐ N/A
3	Do all unverified assumptions have a tracking and closure mechanism in place?	**If** there are unverified assumptions without a tracking mechanism indicated, **then** create the tracking item either through an ATI or a work order attached to the implementing WO. Due dates for these actions need to support verification prior to the analysis becoming operational or the resultant plant change being op authorized.	☐ Yes ☐ No ☒ N/A
4	Do the design inputs have sufficient rationale?	The origin of the input, or the source should be identified and be readily retrievable within Exelon's documentation system. If not, then the source should be attached to the analysis. Ask yourself, would you provide more justification if you were performing this analysis? **If** yes, the rationale is likely incomplete.	☒ Yes ☐ No ☐ N/A
5	Are design inputs correct and reasonable with critical parameters identified, if appropriate?	The expectation is that an Exelon Engineer should be able to clearly understand which input parameters are critical to the outcome of the analysis. That is, what is the impact of a change in the parameter to the results of the analysis? If the impact is large, then that parameter is critical.	☒ Yes ☐ No ☐ N/A
6	Are design inputs compatible with the way the plant is operated and with the licensing basis?	Ensure the documentation for source and rationale for the inputs supports the way the plant is currently or will be operated post change and they are not in conflict with any design parameters.	☒ Yes ☐ No ☐ N/A

ATTACHMENT 2
Owner's Acceptance Review Checklist for External Design Analyses
Page 2 of 3

Design Analysis No.: 13-0541-TR-002 **Rev:** 1

No	Question	Instructions and Guidance	Yes / No / N/A
7	Are Engineering Judgments clearly documented and justified?	See Section 2.13 in CC-AA-309 for the attributes that are sufficient to justify Engineering Judgment. Ask yourself, would you provide more justification if you were performing this analysis? **If** yes, the rationale is likely incomplete.	☒ Yes ☐ No ☐ N/A
8	Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis?	Ensure the justification for the engineering judgment supports the way the plant is currently or will be operated post change and is not in conflict with any design parameters. **If** the Analysis purpose is to establish a new licensing basis, **then** this question can be answered yes, if the judgment supports that new basis.	☒ Yes ☐ No ☐ N/A
9	Do the results and conclusions satisfy the purpose and objective of the Design Analysis?	Why was the analysis being performed? Does the stated purpose match the expectation from Exelon on the proposed application of the results? **If** yes, **then** the analysis meets the needs of the contract.	☒ Yes ☐ No ☐ N/A
10	Are the results and conclusions compatible with the way the plant is operated and with the licensing basis?	Make sure that the results support the UFSAR defined system design and operating conditions, or they support a proposed change to those conditions. If the analysis supports a change, are all of the other changing documents included on the cover sheet as impacted documents?	☒ Yes ☐ No ☐ N/A
11	Have any limitations on the use of the results been identified and transmitted to the appropriate organizations?	Does the analysis support a temporary condition or procedure change? Make sure that any other documents needing to be updated are included and clearly delineated in the design analysis. Make sure that the cover sheet includes the other documents where the results of this analysis provide the input.	☐ Yes ☐ No ☒ N/A
12	Have margin impacts been identified and documented appropriately for any negative impacts (Reference ER-AA-2007)?	Make sure that the impacts to margin are clearly shown within the body of the analysis. If the analysis results in reduced margins ensure that this has been appropriately dispositioned in the EC being used to issue the analysis.	☒ Yes ☐ No ☐ N/A
13	Does the Design Analysis include the applicable design basis documentation?	Are there sufficient documents included to support the sources of input, and other reference material that is not readily retrievable in Exelon controlled Documents?	☒ Yes ☐ No ☐ N/A
14	Have all affected design analyses been documented on the Affected Documents List (ADL) for the associated Configuration Change?	Determine if sufficient searches have been performed to identify any related analyses that need to be revised along with the base analysis. It may be necessary to perform some basic searches to validate this.	☐ Yes ☐ No ☒ N/A
15	Do the sources of inputs **and** analysis methodology used meet committed technical and regulatory requirements?	Compare any referenced codes and standards to the current design basis and ensure that any differences are reconciled. If the input sources **or** analysis methodology are based on an out-of-date methodology or code, additional reconciliation may be required if the site has since committed to a more recent code	☒ Yes ☐ No ☐ N/A

ATTACHMENT 2
Owner's Acceptance Review Checklist for External Design Analyses
Page 3 of 3

Design Analysis No.: 13-0541-TR-002 **Rev:** 1

No	Question	Instructions and Guidance	Yes / No / N/A
16	Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary?	Based on the risk assessment performed during the pre-job brief for the analysis (per HU-AA-1212), ensure that sufficient reviews of any supporting documents not provided with the final analysis are performed.	☒ ☐ ☐
17	Do operational limits support assumptions and inputs?	Ensure the Tech Specs, Operating Procedures, etc. contain operational limits that support the analysis assumptions and inputs.	☒ ☐ ☐
18.	List the critical characteristics of the product, and validate those critical characteristics. N/A		

Create an SFMS entry as required by CC-AA-4008. SFMS Number: N/A

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REVISION SUMMARY

Rev. No.	Description of Changes	Page(s) Revised	Dated
1	Issued for Use – Comments by Exelon's Jason Ritzel 8/1/19 Incorporated	-	8/2/19
0 B	Draft Issue with Exelon Review Comments on Revision 0 A Incorporated. 7/15/19 J. Ritzel	-	7/31/2019
0 A	Revised (Entergy) Cover Sheet Per Exelon Requirements	1	6/28/19
0 A	Eliminated (Entergy) Recommendation for Approval Form. Page is intentionally blank.	2	6/28/19
0 A	Revised Revision Summary	3	6/28/19
0 A	Updated Table of Contents, Tables and Figures. As additional information was added page numbers, table and figure numbers have changed.	TOC	6/28/19
0 A	Updated Attachment Tables	TOC	6/28/19
0 A	Minor administrative edits throughout the report for consistency.	Entire Document	6/28/19
0 A	Added New/ Missing Acronyms: DE&S, FB, GEH, IR, LC, NYPA, PS1, PS2, PSI, PS0, PS0I, PST, S_H. SLP, TE and VCL.	Table 1 Page 22	6/28/19
0 A	Added additional discussion of Vent Clearing, Pool Swell Fall Back and Inertia Load Conditions. Also added submergence definitions.	Table 2 Page 28	6/28/19
0 A	Adjusted Corrosion Allowance discussion. Kinectrics Calculation A384.F02-15 changed the corrosion allowance to 0.100 in for the lower-half of the torus shell and this document demonstrated acceptability of 0.143 in.	Section 2.8 Page 34	6/28/19
0 A	Added ECCS Suction Strainer Material SA240	Table 11 Page 52	6/28/19
0 A	Rewritten and expanded to address the 2018 Upgrade of the ECCS RHR Suction Strainers.	Section 2.17	6/28/19

	Section 2.17.2 2018 Upgrade was added. Section 2.17.3 was added to address the timing of PS inertia and Fall Back load conditions.	Page 56	
0 A	A discussion of the ECCS Suction Strainer Modification was added at the end this section.	Section 3.1 Page 65	6/28/19
0 A	Added to address the latest GEH short term transient analysis report for Mk I Program hydrodynamic load development. Table 15 – Vent Header Thrust Load Comparison was also included. It demonstrates adequate margin available to increase submergence by 3 inches.	Section 5.2.4 Page 70	6/28/19
0 A	The torus corrosion allowance was updated for the lower torus shell limit discussed by Kinectrics in calculation A384.F02-15 that was later eliminated.	Section 5.2.6 Page 72	6/28/19
0 A	Modified to include additional information on the R23 RHR Suction Strainer Clamshell modification.	Section 5.2.7 Page 72	6/28/19
0 A	Modified discussion to include acceptability of the current corrosion allowance of 0.143 inches.	Section 5.3 Page 72	6/28/19
0 A	Modified to discuss the results of the 1998 upgrade and the R23 RHR Strainer modification for the ECCS and RCIC Suction Strainers.	Section 5.8 Page 83	6/28/19
0 A	Modified to include the ECCS and RCIC Suction Strainers results of the 1998 upgrade including the R23 RHR Strainer modification.	Section 5.10.2 Page 86	6/28/19
0 A	Modified to include the ECCS and RCIC Suction Strainers results of the 1998 upgrade including the R23 RHR Strainer modification. VH/VP Allowable/ Actual IR = 1.22 based on recalculation with reduced conservatism. Outer Column Clamping Plate Anchor Bolts Allowable/ Actual IR = 2.06 based on recalculation with reduced conservatism.	Section 5.11 Page 89	6/28/19
0 A	Updated based on the results to include a Submergence of +3 inches to 14.25 ft.	Section 6.0 Page 91	6/28/19
0 A	References were added based on information provided:	Section 7.0	6/28/19

	7.1.5, 7.2.9, 7.4.10, 7.4.11, 7.4.12, 7.4.62 through 7.4.95, 7.5.13 and 7.7.11. Note: Reference numbers were added at the end of sections to avoid reference number changes to existing references.	Page 92	
0 A	Table Notes were added to Table B-8 and B-9. Outer and Inner Column Clamping Plate Anchor Bolt IRs were recalculated. The original evaluation was overly conservative.	Attachment B	6/28/19
0 A	Table D-7 Vent Header/ Vent Pipe resultant stress at 0.0 ΔP PS NO was recalculated to remove conservatism for signed loads.	Attachment D	6/28/19
0 A	This attachment was totally rewritten based on the results from the Clamshell Modification installed during R23.	Attachment F	6/28/19
0 A	Tables numbers were shifted due to added information and reformatting. Added TAP X-225 A & B RHR Pump Suction Piping Added TAP X-227 A Core Spray Suction Piping Added TAP X-227 B Core Spray Suction Piping	Attachment I	6/28/19
0	Initial Issue (JAF Report Review Comments are addressed.)		05/31/2018
A	Draft Issue		03/14/2018

TABLE OF CONTENTS

DESIGN ANALYSIS COVER SHEET 1

REVISION SUMMARY 3

TABLE OF CONTENTS 6

LIST OF TABLES 10

LIST OF FIGURES 11

1.0 INTRODUCTION 22
1.1 Scope 22
1.2 Objective 22
1.3 Acronyms 22
1.4 Terminology 27

2.0 INPUT INFORMATION AND ASSUMPTIONS 33
2.1 Metal Temperature for PS Evaluation 33
2.2 Bounding SRV Evaluation 33
2.3 PS Fatigue Evaluation Requirements 33
2.4 Event Combinations with SRV and EQ 34
2.5 FEM Refinement - TES 1/32nd vs. Altran 1/16th 34
2.6 PS DLF 34
2.7 Determination of Torus Shell Stress for Individual Load Conditions 34
2.8 Corrosion Allowance 34
2.9 DISTRES Information 35
2.10 Load Condition Adjustment Factors 35
2.10.1 Vent System Thrust 36
2.10.2 0.0 ΔP ↓ Mk I PS Download Phase Pressure Adjustment 36
2.10.3 0.0 ΔP ↑ Mk I PS Upload Phase Pressure Adjustment 37
2.10.4 0.0 ΔP Mk I LOCA Jet & Bubble 38
2.10.5 0.0 ΔP Mk I Impact and Drag 38
2.10.6 0.0 ΔP Mk I - PS Froth Impingement Phase 39
2.10.7 0.0 ΔP Mk I – PS Fallback 40
2.10.8 0.0 ΔP & +3-inch Submergence SRV Jet & Bubble Phase 41

2.10.9 Post Mk I Program - 4.1% Thermal Power Uprate and ARTS/ MEOD Power Uprate 41
2.10.10 Post Mk I Program - Water in Vent Pipe Bowl 42
2.10.11 Post Mk I Program - 3-Stage SRV Replacements 42
2.10.12 Post Mk I Program - Plus Three-Inch Submergence Increase (50 to 53 inches) 43
2.10.13 0.0 ΔP PS Dynamic Load Factor 46
2.10.14 Earthquake Load 46
2.11 Bounding Event Combinations 47
2.11.1 Structural Elements 47
2.11.2 TAP (CI-2 &CI-3) 48
2.12 Updated Construction Code 48
2.12.1 Original Construction Codes of Record 48
2.12.2 Mk I Program Updated Construction Codes of Record 48
2.12.3 Construction Code of Record – Normal Operation at 0.0 ΔP 49
2.13 Materials and Allowable Stress Intensity Information 51
2.14 Weld Allowable Stress Values 52
2.15 Torus Support System 54
2.16 Mark I Long-Term Containment Program, Evaluation of the Torus Vent System for Increased Thrust Loads Due to Water in the Vent Pipe Bowl 54
2.16.1 Discussion 54
2.16.2 Methodology 55
2.16.3 Conclusion 55
2.17 Torus ECCS and RCIC Suction Strainers 56
2.17.1 1998 Upgrade 56
2.17.2 2018 Upgrade 56
2.17.3 Mark I Program Hydrodynamic Load Conditions for 0.0 ΔP NO - Summary 60
3.0 DISCUSSION 65
3.1 Structural Element Evaluation 65
3.2 SRV Discharge Lines 65
3.3 TAP Evaluation 65
4.0 METHODOLOGY 66
5.0 SUMMARY OF RESULTS 67
5.1 Load Condition Adjustment Factors 67
5.2 Post MKI Program Modifications 69

5.2.1 Water–in-Vent Pipe Bowl ... 69
5.2.2 Torus Water Level – Increased Submergence ... 69
5.2.3 Power Uprate ... 70
5.2.4 GEH Mark I Program Containment Analysis 2019 Update ... 70
5.2.5 3 Stage SRV Installation ... 72
5.2.6 Torus Corrosion Allowance ... 72
5.2.7 ECCS and RCIC Suction Strainers ... 72
5.2.8 Penetration X-214 HPCI Steam Discharge Sparger Modification ... 72
5.3 Torus Shell Stress Evaluation ... 72
5.4 Torus Support System and Attachment Weld Evaluation ... 75
5.4.1 Saddle ... 75
5.4.2 Inner and Outer Column ... 75
5.4.3 Column to Shell Weld ... 77
5.4.4 Saddle to Shell Weld, Clamping Plate and Anchors ... 77
5.5 Ring Girder Evaluation ... 78
5.5.1 RG Flange and Web Stresses ... 78
5.5.2 RG Welds ... 78
5.6 Vent System Evaluation ... 79
5.6.1 Vent Header/ Downcomer Intersection ... 79
5.6.2 Vent Header/ Vent Pipe Intersection ... 79
5.6.3 Vent Header Support Columns and Attachments ... 80
5.6.4 Vent Header/ Downcomer Tie-Bars and Attachments ... 81
5.6.5 Vent Header Deflector and Attachments ... 81
5.6.6 Vent Header Main Vent/ Drywell Intersection ... 81
5.6.7 Vent Header, Main Vent and Downcomer – Free Shell Stresses ... 82
5.6.8 Vent Header Mitre Joint ... 82
5.6.9 Vent Header – Fatigue Evaluation ... 82
5.7 T-Quencher ... 83
5.8 Emergency Core Cooling and Reactor Core Isolation Cooling Suction Strainers ... 83
5.9 Miscellaneous Structures ... 84
5.9.1 Catwalk ... 84
5.9.2 Spray Header ... 84
5.9.3 Vent Pipe Bellows Displacement Evaluation ... 85
5.9.4 Monorail ... 86

5.10 Torus Attached Piping 86
5.10.1 Safety Relief Valve Discharge Lines 86
5.10.2 TAP Large Bore 86
5.10.3 TAP Small Bore 88
5.11 Summary of Structural Element and TAP Review 89

6.0 CONCLUSIONS AND RECOMMENDATIONS 91

7.0 REFERENCES 92

A. TORUS SHELL EVALUATION FOR 0.0 ΔP NORMAL OPERATION 1

B. TORUS COLUMN, SADDLE AND ASSOCIATED WELD EVALUATION FOR 0.0 ΔP NORMAL OPERATION 1

C. TORUS RING GIRDER AND ASSOCIATED WELD EVALUATION FOR 0.0 ΔP NORMAL OPERATION 1

D. VENT HEADER SYSTEM STRESS EVALUATION 1

E. T-QUENCHER AND SUPPORT STRESS EVALUATION 1

F. EMERGENCY CORE COOLING AND RCIC SYSTEM SUCTION STRAINERS 1

G. OTHER STRUCTURES 1

H. SAFETY RELIEF VALVE DISCHARGE LINES 1

I. TORUS ATTACHED PIPING 1
X-214 HPCI Turbine Exhaust Piping 1
X-226 HPCI Pump Suction Piping 19
X-212 RCIC Turbine Exhaust Piping 38
X-224 RCIC Pump Suction Piping 50
X-228 Condensate Drain Line Piping 57
X-205 Reactor Building Normal Vent Piping 64
X-202B/G Vacuum Relief Line 70
X-220 Vent Purge Outlet Piping 78
X-210B & X-211B RHR Discharge Piping 85
X-202A/F Vacuum Relief Line Piping 96
X-225A & B RHR Pump Suction Piping 104
X-227A Core Spray Pump Suction Piping 138
X-227B Core Spray Pump Suction Piping 151

X-210A & X-211A RHR Discharge Piping 163
X-213A/B Drain Piping 172
Small Bore Torus Attached Piping 181

J. CONTAINMENT DP FEASIBILITY STUDY 1

K. IMPERIA REPORT RECORD 1

L. IMPERIA VERIFICATION FORM 1

LIST OF TABLES

Table 1 – List of System Acronyms 22
Table 2 - Terminology 28
Table 3 - Vent System Thrust Load from PUAR 36
Table 4 - LOCA Loads – Vent Header Support Analysis 38
Table 5 - PS Maximum Shell Pressure 38
Table 6 - QSTF Pool Velocity for Froth Region I 40
Table 7 - QSTF Pool Velocity for Froth Region II 40
Table 8 - Consideration of Water Weight Adjustment for +2 Inch Submergence 44
Table 9 - Comparison of FEM PS Reaction Loads (Kips) 46
Table 10 - PUAAG PS Event Combinations 47
Table 11 - ASME BPVC Material Properties 52
Table 12 - Double Sided Weld Example 53
Table 13 - Load Condition Adjustment Factors for Structural Element Evaluation 67
Table 14 - Load Condition Adjustment Factors for +3” Increased Submergence 70
Table 15 – Vent Header Thrust Load Comparison 71
Table 16 - Comparison of Normal Operation P_M and P_L+P_B Stress Intensity Results 73
Table 17 - Torus Shell Controlling Event Combinations 73
Table 18 - Torus Column Axial Plus Bending Stress Ratio for Controlling EC 25 PS ↓Download Phase 75
Table 19 - EC 25 PS ↑ Upload Phase for Column Components 76
Table 20 - Results for Bounding Outer Column to Shell Weld Stress based on 1/16th Model FEA 77
Table 21 - Controlling RG Web and Flange Stress Intensity EC 25 0.0 ΔP PS ↓ Download Phase NO 78
Table 22 - RG to Shell Average Weld Load 0.0 ΔP (NO) EC 18 – 1/16th Model Results 78
Table 23 - Controlling Stress in VH/DC Intersection - 0.0 ΔP NO 79

Table 24 - Controlling Stress in VH/VP Intersection - 0.0 ΔP NO 80
Table 25 - Controlling Stress in VH Support Columns and Attachments EC 25 - 0.0 ΔP NO 80
Table 26 - Controlling Stress in VH/ Downcomer Tie-Bars - 0.0 ΔP NO 81
Table 27 - Controlling Stress in VH Deflector and Attachment - 0.0 ΔP NO 81
Table 28 - Controlling Stress in VH Main Vent/ Drywell Intersection - 0.0 ΔP NO 82
Table 29 - Controlling Stress in VH Mitre Joint - 0.0 ΔP NO 82
Table 30 - Controlling Stresses in T-Quencher, Attached Vertical Piping and Support - 0.0 ΔP NO 83
Table 31 - Controlling Stresses in Catwalk - 0.0 ΔP NO 84
Table 32 - Controlling Stresses in Spray Header, Supports and Attachment Welds - 0.0 ΔP NO 85
Table 33 - VP Bellows Drywell/ Torus Differential Displacements - 0.0 ΔP NO 85
Table 34 - Controlling Stress in Monorail Beam, Supports and Attachment Welds - 0.0 ΔP NO 86
Table 35 - Large Bore TAP Summary Table for Allowable/Actual Ratios 87
Table 36 - Large Bore TAP Support Summary Table Ratios 88
Table 37 - Small Bore TAP Summary Table for Maximum Allowable/ Actual Ratios 88
Table 38 – Controlling Allowable/ Actual Ratio for Structural Elements - 0.0 ΔP NO 89

ATTACHMENT "A" TABLES

Table A-1 - Torus Shell Controlling Event Combinations 1
Table A-2 - Controlling ECs 18 and 25 6

ATTACHMENT "A" FIGURES

Figure A-1 Shell Element Location for 1/32nd Model by TES [7.4.5 Page 17 of 234] 7

ATTACHMENT "B" TABLES

Table B-1 - Comparison of FEM PS Download Phase Reaction Loads (Kips) 1
Table B-2 - TES Saddle Loads Bounding Event Combinations/ Load Conditions 2
Table B-3 - Torus Column 0 ΔP PS NO Download based on 1/16th Model FEA 3
Table B-4 - Torus Column Stress Reported by Teledyne 4
Table B-5 - Buckling Loads along Minor Axis for Torus Support Columns 5
Table B-6 - Column Stresses about Major Axis – EC 25 6
Table B-7 - TES Calculated Event Combinations for PS ↑ Upload Phase 7
Table B-8 - Controlling Load Comparison for PS ↑ Upload Phase 7
Table B-9 - EC 25 PS ↑ Upload Phase for Column Components 8
Table B-10 - Column to Shell Weld Stress Results Based on TES 1/32nd Model FEA 9
Table B-11 - EC 16 Drag Loads - Column to Shell Weld Location 10
Table B-12 - EC 25 Drag Loads - Column to Shell Weld Location 10

Table B-13 - Results for Bounding Outer Column to Shell Weld Stress based on 1/16th Model FEA.......11
Table B-14 - Saddle and Saddle to Shell Weld Stress Results Based on 1/32nd Model FEA...................12

ATTACHMENT "C" TABLES

Table C-1 - Ring Girder and Ring Girder to Shell Weld Stress Results TES FEA 1
Table C-2 - Ring Girder Stress EC 16 Results – Teledyne Model 2
Table C-3 - Ring Girder Stress EC 25 0.0 ΔP ↓ Download NO 3
Table C-4 - Ring Girder to Shell Weld Load N+0.0 ΔP PS Results – 1/16th Model 4
Table C-5 - TES Ring Girder to Shell Weld Worst Download 0.0 ΔP (Accident Condition) EC 16 – 1/32nd Model Results 4
Table C-6 - TES Ring Girder to Shell Weld Download 1.7 ΔP (NO) EC 25 – 1/32nd Model Results 6
Table C-7 - Ring Girder to Shell Average Weld Load 0.0 ΔP (NO) EC 18 – 1/16th Model Results 7
Table C-8 - Ring Girder to Shell Average Weld Load 0.0 ΔP (NO) EC 25 – 1/16th Model Results 8

ATTACHMENT "D" TABLES

Table D-1 - Controlling Stress in Vent Header/ Downcomer Intersection – TES 1
Table D-2 - Controlling Stress in VH/DC Intersection - 0.0 ΔP NO..1
Table D-3 - Controlling Stress in VH/VP Intersection – TES 2
Table D-4 - VH/VP Intersection Loads at Node 1 Element 10 - 1.7 ΔP NO 3
Table D-5 - VH/VP Intersection Loads at Node 1 Element 10 - 0.0 ΔP NO 3
Table D-6 - VH/VP Intersection Loads at Node 1 Element 10– PS Max and Min Loads 4
Table D-7 - VH/VP Intersection EC18 and EC 25 Loads at 0.0 ΔP Normal Operation 5
Table D-8 - Controlling Stress Reported for VH Support Components - TES 5
Table D-9 - Summary of VH Support Axial Loads at 1.7 ΔP NO - TES...6
Table D-10 - Summary of Vent Header Supports Axial Loads - 0.0 ΔP NO..7
Table D-11 - Vent Header Column Evaluation - Tension and Bending EC 25 - 0.0 ΔP NO.........................8
Table D-12 - Vent Header Pin Evaluation for Bearing EC 25 - 0.0 ΔP NO...9
Table D- 13 - Review of Remaining VH Column Components 9
Table D-14 - Controlling Stress in Vent Header Downcomer Tie-Bars – Teledyne....................................10
Table D-15 - Maximum Loads on the Tie-Bar Clamp 10
Table D-16 - Controlling Stress in VH/ Downcomer Tie-Bars – 0.0 ΔP NO...11
Table D-17 - Controlling Stress in Vent Header Deflector and Attachments – TES 11

Table D-18 - Weld Stress in Vent Header Deflector Components ... 12
Table D-19 - Controlling Stress in VH Deflector and Attachment – 0.0 ΔP NO ... 12
Table D-20 - Controlling Stress in VH Main Vent/ Drywell Intersection – TES ... 13
Table D-21 - Controlling Stress in VH Main Vent/ Drywell Intersection – 0.0 ΔP NO ... 13
Table D-22 - Controlling Stress at VH Mitre Joint – TES ... 14
Table D-23 - VH Mitre Joint Loads at Node 16 Element 14 - 1.7 ΔP NO ... 14
Table D-24 - VH Mitre Joint Loads at Node 16 Element 14 - 0.0 ΔP NO ... 15
Table D-25 - VH Mitre Joint Loads at Node 16 Element 14– PS Loads ... 15
Table D-26 - VH Mitre Joint EC18 and EC 25 Loads - 0.0 ΔP NO ... 16
Table D-27 - Controlling Stress in VH Mitre Joint – 0.0 ΔP NO ... 16
Table D-28 - Fatigue Stress in Vent Header Supports – Teledyne ... 17

ATTACHMENT “E” TABLES

Table E-1 - Controlling Stress in T-Quencher Bifurcated Elbow – TES ... 1
Table E-2 - Load Condition Stress in T-Quencher Bifurcated Elbow ... 1
Table E-3 - Controlling Stress in the T-Quencher Bifurcated Elbow DL – 0.0 ΔP NO ... 2
Table E-4 - Controlling Stress in the Submerged Portion of Vertical SRV DL – TES ... 2
Table E-5 - Load Condition Stress in the Submerged Portion of Vertical SRV DL ... 3
Table E-6 - Controlling Stress in the Submerged Portion of Vertical SRV DL – 0.0 ΔP NO ... 4
Table E-7 - Controlling Stress in T-Quencher Support – TES ... 4
Table E-8 - Controlling Stress in T-Quencher Support Calculation ... 5
Table E-9 - Controlling Stress in T-Quencher Support – 0.0 ΔP NO ... 6

ATTACHMENT “G” TABLES

Table G-1 - Controlling Stress in Catwalk – TES ... 1
Table G-2 - 0.0 ΔP NO Loads for Catwalk Support Columns and End Joint ... 2
Table G-3 - 0.0 ΔP NO EC for Welds to Ring Girder ... 3
Table G-4 - Controlling Stress in Catwalk - 0.0 ΔP NO ... 3
Table G-5 - Controlling Stress in Spray Header, Supports and Attachment Welds – TES ... 4
Table G-6 - Controlling Stress in Spray Header, Supports and Attachment Welds – 0.0 ΔP NO ... 5
Table G-7 - VP Bellows Drywell/ Torus Differential Displacements – TES ... 5
Table G-8 - VP Bellows Drywell/ Torus Differential Displacements – 0.0 ΔP NO ... 6
Table G-9 - Controlling Stress in Monorail – TES ... 6

Table G-10 - Controlling Stress in Monorail Beam, Supports and Attachment welds, 0.0 ΔP NO 7

ATTACHMENT "I" TABLES

Table I-1 - Reported Pipe Stress Results X-214 - TES 1
Table I-2 - Individual Load Condition Contributions per EC X-214 - TES........ 2
Table I-3 - PS and CO/CH load cases at Pipe Support X-214 - TES 3
Table I-4 - Reported Penetration Stress Results X-214 - TES 4
Table I-5 - Reported Individual Penetration Loads X-214 - TES 4
Table I-6 - PS Load Adjusted for 0.0 ΔP Normal Operation X-214 – TES........ 5
Table I-7 - Reported ECs – Forces and Moments X-214 - TES 5
Table I-8 - Adjusted ECs – Forces and Moments X-214 - TES 5
Table I-9 - Reported Stress Results from X-214 for 2"-SLP-152-49 - TES 6
Table I-10 - Individual Load Condition Contributions per EC from X-214 for 2"-SLP-152-49 - TES 7
Table I-11 - Reported Stress Results from X-214 for 1"-WO-152-48 - TES 8
Table I-12 - Individual Load Condition Contributions per EC from X-214 for 1"-WO-152-48 - TES 9
Table I-13 - EC 25 from 1.7 ΔP to NO 0.0 ΔP Update X-214 - TES 9
Table I-14 - VGW-15AN and VCW-15AN EC25 Valve Analysis X-214 - TES........ 10
Table I-15 - Reported Pipe Stress Results X-214 - JAF-CALC-06-00030........ 10
Table I-16 - Individual Load Condition Contributions per EC X-214 - JAF-CALC-06-00030........ 11
Table I-17 - PS and DBACO Load Conditions at Pipe Support (unit: lbf) X-214 - JAF-CALC-06-00030 ... 12
Table I-18 - 0.0 ΔP PS for Pipe Support PSFK-2247 X-214 - JAF-CALC-06-00030........ 13
Table I-19 - 0.0 ΔP PS NO for Pipe Support PSFK-2247 X-214 -- JAF-CALC-06-00030 13
Table I-20 - Reported Penetration Stress Results X-214 - JAF-CALC-06-00030 14
Table I-21 - Reported Individual Penetration Loads X-214 - JAF-CALC-06-00030........ 14
Table I-22 - PS Load Adjusted for 0.0 ΔP Normal Operation X-214 - JAF-CALC-06-00030........ 15
Table I-23 - Reported Event Combinations – Forces and Moments X-214 - JAF-CALC-06-00030........ 15
Table I-24 - Adjusted Event Combinations – Forces and Moments X-214 - JAF-CALC-06-00030........ 15
Table I-25 - Branch Line Displacement by Load X-214 - JAF-CALC-06-00030 16
Table I-26 - Displacement for 5 ECs of Branch Lines X-214 - JAF-CALC-06-00030 17
Table I-27 - Branch Line Stress Results - Controlling EC 5 X-214 - JAF-CALC-06-00030 17
Table I-28 - VGW-15AN and VCW-15AN Valve Acceleration Analysis X-214 - JAF-CALC-06-00030 18
Table I-29 - X-214 Summary of Results Table........ 18
Table I-30 - Reported Pipe Stress Results X-226 - TES 19
Table I-31 - Individual Load Condition Contributions per EC X-226 - TES........ 20

Table I-32 - PS load cases at Pipe Support X-226 - TES 21
Table I-33 - Reported Penetration Stress Results X-226 - TES 22
Table I-34 - Reported Individual Penetration Loads - X-226 - TES 22
Table I-35 - PS Load Adjusted for 0.0 ∆P Normal Operation X-226 - TES 22
Table I-36 - Reported Event Combination Forces and Moments X-226 - TES 23
Table I-37 - Adjusted Event Combinations Forces and Moments X-226 - TES 23
Table I-38 - Reported Stress Results for 1”-W25-152-18 X-226 - TES 24
Table I-39 - Individual Load Condition Contributions per EC for 1”-W25-152-18 X-226 - TES 25
Table I-40 - Reported Stress Results for ¾ in Vent Line X-226 - TES 26
Table I-41 - Individual Load Condition Contributions per EC for 3/4 in Vent Line X-226 - TES 27
Table I-42 - EC 25 from 1.7 ∆P to NO 0.0 ∆P Update X-226 - TES 28
Table I-43 - EC25 Valve Analysis X-226 - TES 28
Table I-44 - Reported External Pipe Stress Results X-226 – DE&S 29
Table I-45 - Maximum External Piping Stress EC25 for 0.0 ∆P NO X-226- DE&S 30
Table I-46 - Maximum Pipe Support Loads EC25 for 0.0 ∆P NO X-226- DE&S 31
Table I-47 - Reported Penetration Stress Results X-226 – DE&S 33
Table I-48 - Reported Individual Penetration Loads X-226 – DE&S 33
Table I-49 - PS Load Adjusted for 0.0 ∆P Normal Operation X-226 – DE&S 34
Table I-50 - Adjusted EC – Forces and Moments X-226 – DE&S 34
Table I-51 - Local Membrane Stress 0.0 ∆P PS NO X-226 – DE&S 35
Table I-52 - Adjusted Penetration Stress Results X-226 – DE&S 36
Table I-53 - Other Components Loads/Stress for 0.0 ∆P NO X-226- DE&S 36
Table I-54 - X-226 Summary of Results Table 37
Table I-55 - Reported Pipe Stress Results X-212 38
Table I-56 - Individual Load Condition Contributions per EC X-212 39
Table I-57 - PS load cases at Pipe Support X-212 40
Table I-58 - Moments Reported by TES at Pipe Support PFSK-1963 X-212 41
Table I-59 - Reported Penetration Stress Results X-212 41
Table I-60 - Reported Individual Penetration Loads X-212 42
Table I-61 - PS Forces and Moments Adjusted for 0.0 ∆P NO X-212 42
Table I-62 - TES Reported EC – Forces and Moments X-212 43
Table I-63 - Adjusted EC – Forces and Moments X-212 43
Table I-64 - Reported Stress Results for 1.5"-SLP-152-51 - X-212 44
Table I-65 - Individual Load Condition Contributions per EC – X-212 45

Table I-66 - Reported Stress Results from X-212 for 1"-SLP-152-25 46
Table I-67 - Individual Load Condition Contributions per Event Combination 47
Table I-68 - EC 25 from 1.7 ∆P to NO 0.0 ∆P Update X-212 48
Table I-69 - VGW-15AN and VCW-15AN EC25 Analysis X-212 48
Table I-70 - VGW-15AN and VCW-15AN Maximum Stress Analysis X-212 48
Table I-71 - X-212 Summary of Results Table 49
Table I-72 - Reported Pipe Stress Results X-224 50
Table I-73 - Individual Load Condition Contributions per Event Combination X-224 51
Table I-74 - PS load cases at Pipe Support 52
Table I-75 - Reported Penetration Stress Results X-224 53
Table I-76 - Reported Individual Penetration Loads X-224 53
Table I-77 - PS Load Adjusted for 0.0 ∆P Normal Operation X-224 53
Table I-78 - Reported EC Forces and Moments X-224 54
Table I-79 - Adjusted EC Forces and Moments X-224 54
Table I-80 - Adjusted Penetration Stress Results X-224 55
Table I-81 - Reported Stress Results from X-224 55
Table I-82 - Stresses in Valves/Pump X-224 56
Table I-83 - X-224 Summary of Results Table 56
Table I-84 - Reported Pipe Stress Results from X-228 57
Table I-85 - Individual Load Condition Contributions per EC X-228 58
Table I-86 - PS load cases at Pipe Support X-228 59
Table I-87 - Reported Torus Internal Pipe Support Loads X-228 59
Table I-88 - Torus Force and Moment Results for Internal Pipe Support Shell and Penetration Evaluation X-228 60
Table I-89 - Reported Penetration Stress Results X-228 61
Table I-90 - Reported Individual Penetration Loads X-228 61
Table I-91 - PS Load Adjusted for 0.0 ∆P NO X-228 61
Table I-92 - Reported EC Forces and Moments X-228 62
Table I-93 - Adjusted EC Forces and Moments X-228 62
Table I-94 - Pipe Stress at Valves & Pumps X-228 63
Table I-95 – X-228 Summary of Results Table 63
Table I-96 - Reported Pipe Stress Results from X-205 64
Table I-97 - Individual Load Condition Contributions per Event Combination X-205 64
Table I-98 - Support Evaluation for 0.0 ∆P NO X-205 66

Table I-99 - Reported Penetration Stress Results X-205 67
Table I-100 - Reported Penetration Loads X-205 67
Table I-101 - Penetration Loads 0.0 ΔP NO X-205 68
Table I-102 - Reported Valves/Pump Accelerations X-205 (g) 69
Table I-103 - Valves/Pump Accelerations 0.0 NO X-205 (g) 69
Table I-104 - X-205 Summary of Results Table 69
Table I-105 - Reported Pipe Stress Results X-202B/G 70
Table I-106 - Individual Load Condition Contributions per EC X-202B/G 71
Table I-107 - Reported VP Penetration Stress Results X-202G 72
Table I-108 - Reported Individual Pipe/ VP Penetration Loads X-202G 72
Table I-109 - Pipe/ VP Penetration PS Load Adjusted for 0.0 ΔP NO X-202G 72
Table I-110 - Reported Pipe/ VP Penetration EC Forces and Moments X-202G 73
Table I-111 - Adjusted Pipe/ VP Penetration EC Forces and Moments X-202G 73
Table I-112 - Reported Individual VP/ Penetration Loads X-202G 73
Table I-113 – VP/ Penetration PS Load Adjusted for 0.0 ΔP NO X-202G 74
Table I-114 - Reported VP/ Penetration EC Forces and Moments X-202G 74
Table I-115 - Adjusted VP/ Penetration EC Forces and Moments X-202G 74
Table I-116 - Updated VP Penetration Stress Results X-202G 75
Table I-117 - Reported Torus Penetration Stress Results X-202B 75
Table I-118 - Reported Individual Torus Penetration Loads X-202B 75
Table I-119 - PS Load Adjusted for 0.0 ΔP NO X-202B 76
Table I-120 - Reported EC Forces and Moments X-202B 76
Table I-121 - Adjusted EC Forces and Moments X-202B 76
Table I-122 - Valves and Pump Stresses X-202B/G 77
Table I-123 - X-202 B/G Summary of Results Table 77
Table I-124 - Reported Pipe Stress Results from X-220 78
Table I-125 - Individual Load Condition Contributions per EC X-220 79
Table I-126 - Individual Support Load Condition Contributions EC 25 X-220 80
Table I-127 - Reported Penetration Stress Results X-220 82
Table I-128 - Reported Individual Penetration Loads X-220 82
Table I-129 - PS Load Adjusted for 0.0 ΔP Normal Operation X-220 83
Table I-130 - Reported Envelope/ EC 25 0.0 ΔP PS NO – Forces and Moments X-220 83
Table I-131 - Reported Valves/Pump Accelerations X-220 (g) 83
Table I-132 - Valves/Pump Accelerations 0.0 NO X-220 (g) 84

Table I-133 - X-220 Summary of Results Table 84
Table I-134 - Reported Pipe Stress Results from X-210B/211B – TES & NYPA 85
Table I-135 - LC4 at Node 50 for 0.0 ∆P NO (1) X-210B/211B - TES 86
Table I-136 – X-210B/211B Pipe Support Loads – TES & NYPA 87
Table I-137 - Reported Penetration Stress Results X-210B - TES 88
Table I-138 - Reported Individual Penetration Loads X-210B - TES 89
Table I-139 - PS Load Adjusted for 0.0 ∆P NO X-210B - TES 89
Table I-140 - Reported/ Adjusted EC – Forces and Moments X-210B - TES 90
Table I-141 - Local Membrane Stress at Penetration X-210B 91
Table I-142 - Updated Penetration Stress Results X-210B 92
Table I-143 - Reported Penetration Stress Results X-211A/211B - TES 92
Table I-144 - Reported Individual Penetration Loads X-211A/211B - TES 92
Table I-145 - Reported EC 21 & 25 – Forces and Moments X-211A/211B - TES 93
Table I-146 - Adjusted Branch Line Stress Calculation X-210B/211B TES 93
Table I-147 - Valves/Pump Stresses X-210B/ X-211B 94
Table I-148 - X-210B/X-211B Summary of Results Table 95
Table I-149 - Reported Pipe Stress Results X-202A/F 96
Table I-150 - Individual Load Condition Contributions per EC X-202A/F 97
Table I-151 - Reported Penetration Stress Results X-202A 98
Table I-152 - Reported Individual Penetration Loads X-202A 98
Table I-153 - PS Load Adjusted for 0.0 ∆P Normal Operation X-202A 99
Table I-154 - Reported EC Forces and Moments X-202A 99
Table I-155 - Adjusted EC Forces and Moments X-202A 99
Table I-156 - Reported Penetration Stress Results X-202F 100
Table I-157 - Reported Individual Penetration Loads X-202F 100
Table I-158 - PS Load Adjusted for 0.0 ∆P Normal Operation X-202F 100
Table I-159 - Reported Event Combinations – Forces and Moments X-202F 101
Table I-160 - Adjusted Event Combinations – Forces and Moments X-202F 101
Table I-161 - Valves and Pump Stresses X-202A/F 102
Table I-162 - X-202A/X-202F Summary of Results Table 103
Table I-163 - X-225 A&B Summary of A384.F02-12 Reported Stress Results for ECCS Suction Strainer Piping to the Penetration 104
Table I-164 - X-225 B Summary of TES Reported Stress Results for External Piping to the Penetration 106

Table I-165 - Reported Penetration Forces and Moments from the Torus Internal ECCS Suction Strainer Piping Evaluation - X-225 A&B 107

Table I-166 - Reported Penetration Torus Internal and External Forces and Moments A384.F02-12 ECCS Suction Strainer Piping Evaluation - X-225 A&B 108

Table I-167 – Maximum Reported Penetration Stress Results - X-225 A&B 109

Tables I-168 – Maximum Reported ECCS Suction Strainer Flange Resultant Moments - X-225 A&B 110

Table I-169 – Maximum ECCS Suction Strainer Core Tube Resultant Moments - X-225 A&B 114

Table I-170 – Maximum ECCS Suction Strainer Core Tube Accelerations - X-225 A&B 115

Table I-171 – ECCS Suction Strainer Support Load Summary - X-225 A&B 116

Table I-172 – RHR Pump Load Summary - X-225 A&B 121

Table I-173 –RHR Branch Line Summary - X-225 A&B 122

Table I-174 –ECCS Suction Strainer Submerged Loads Comparison - X-225 A&B 126

Table I-175 –Snubbers Loads PFSK-1936 & PFSK-2072 - X-225 A&B 127

Table I-176 –Snubbers Trunnion Loads PFSK-1936 & PFSK-2072 - X-225 A&B 128

Table I-177 – PFSK-1936 Support Interaction Ratios - X-225 A&B 129

Table I-178 – PFSK-2072 Interaction Ratio X-225 A&B 130

Table I-179 – PFSK-2270 Load Summary - X-225 A&B 131

Table I-180 – PFSK-2270 Interaction Ratio X-225 A&B 132

Table I-181 – PFSK-2238 Load Summary - X-225 A&B 133

Table I-182 – PFSK-2337 Interaction Ratio X-225 A&B 134

Table I-183 – PFSK-2238 Interaction Ratio X-225 A&B 135

Table I-184 – PFSK-2471 Interaction Ratio Adjustment Information X-225 A&B 136

Table I-185 - X-227A Summary of Results Table 137

Table I-186 - X-227A Maximum Stress for External Piping 138

Table I-187 - X-227A Maximum Stress for Internal Piping 139

Table I-188 - X-227A Maximum Penetration Loads 140

Table I-189 - X-227A Maximum Nozzle Loads 141

Table I-190 - Reported Penetration Stress Results X-227A 141

Table I-191 - X-227A NOZZLE AND SUPPORT LOAD SUMMARY 144

Table I-192 - X-227A SUPPORTED ADJUSTED INTERACTION RATIO SUMMARY 146

Table I-193 - X-227A Branch Connection Displacement Tables 149

Table I-194 - X-227A Summary of Results Table 151

Table I-195 - X-227B Maximum Stress for External Piping 151

Table I-196 - X-227B Maximum Stress for Internal Piping 152

Table I-197 - X-227B Maximum Penetration Loads 153

Table I-198 - X-227B Maximum Nozzle Loads 154
Table I-199 - Reported Penetration Stress Results X-227B 154
Table I-200 – Intentionally Blank Table X-227B..... 156
Table I-201 - X-227B NOZZLE AND SUPPORT LOAD SUMMARY 157
Table I-202 - X-227B Support Summary Adjusted Interaction Ratio Summary..... 158
Table I-203 - X-227B Branch Connection Displacement Tables 160
Table I-204 - X-227B Summary of Results Table 162
Table I-205 - Reported Pipe Stress Results from X-210A/211A..... 163
Table I-206 - LC4 for 0.0 ∆P NO (1) - X-210A/211A..... 164
Table I-207 - Reported Penetration Stress Results X-210A 165
Table I-208 - Reported Individual Penetration Loads X-210A 165
Table I-209 - PS Load Adjusted for 0.0 ∆P Normal Operation X-210A 166
Table I-210 - Adjusted Event Combinations – Forces and Moments X-210A 166
Table I-211 - Local Membrane Stress at Penetration X-210A 168
Table I-212 - Updated Penetration Stress Results X-210A 169
Table I-214 - Reported Penetration Stress Results X-211A 169
Table I-215 - Adjusted Branch Line Stress Calculation X-210A/211A..... 170
Table I-216 - Stresses in Valves/Pump X-210A/211A 171
Table I-217 - X-210A/X-211A Summary of Results Table 171
Table I-218 - Reported Pipe Stress Results X-213A/B 172
Table I-219 - Individual Load Condition Contributions per EC X-213A/B 173
Table I-220 - Individual Support LC Contributions Pipe Support 8332 X-213A..... 174
Table I-221 - Individual Support LC Contributions Pipe Support 8333 X-213B..... 175
Table I-222 - Reported Penetration Stress Results X-213A 176
Table I-223 - Reported Individual Penetration Loads X-213A 176
Table I-224 – PS Load Adjusted for 0.0 ∆P NO X-213A..... 176
Table I-225 - Adjusted ECs – Forces and Moments X-213A..... 177
Table I-226 - Updated Penetration Stress Results X-213A 177
Table I-227 – Reported Penetration Stress Results X-213B 178
Table I-228 - Reported Individual Penetration Loads X-213B 178
Table I-229 - PS Load Adjusted for 0.0 ∆P Normal Operation X-213B 178
Table I-230 - Adjusted EC – Forces and Moments X-213B..... 179
Table I-231 - Updated Penetration Stress Results X-213B 179
Table I-232 - Stresses in Valves/Pump X-213AB 180

Table I-233 - X-213A/B Summary of Results Table 180
Table I-234 - Reported Small Bore TAP Pipe Stress 181
Table I-235 - Small Bore Pipe Stress at 0.0 ∆P NO 182
Table I-236 - Reported Small Bore Pipe Penetration Stress Results 183
Table I-237 - Small Bore TAP Valves/Pump Stresses 184
Table I-238 - Small Bore Tap Summary of Results Table 185

1.0 INTRODUCTION

1.1 Scope

Imperia Engineering Partners is contracted to provide James A. FitzPatrick Nuclear Power Plant (JAF) Nuclear Power Plant (NPP) with engineering services in support of the Mark I Torus Suppression Chamber Program (Mk I Program). The results of Altran's initial scoping phase of the subject project demonstrated the feasibility of normal operation (NO) without drywell-to-wetwell differential pressure with an accompanying evaluation for a +3-inch torus level increase. Imperia will generate a Technical Report to provide JAF with the necessary input for the development of a modification package to eliminate the JAF NPP drywell-to-wetwell differential pressure during NO and provide necessary support for the preparation of the accompanying NRC License Amendment/ 10CFR50.59 Safety Evaluation.

1.2 Objective

Imperia will provide the Mk I Program review and documentation necessary to support preparation of an Industry Standard Engineering Change (modification package) to eliminate the requirement for a 1.7 ΔP differential pressure (psi**d**) between the Primary Containment (PC) drywell and torus chamber (Wetwell) during NO. This change will eliminate the surveillance requirement to de-inert and inert the PC to a specific differential pressure which in turn eliminates the need for additional Operations manpower and provides greater operational flexibility while reducing the site nitrogen usage and increases nuclear safety as the plant will no longer be placed in an operational condition that could lead to a faulted event.

1.3 Acronyms

The Mk I Program has several unique acronyms specific to the load conditions and event combinations. The table below is a compiled list of Mk I Program, Code and industry acronyms to facilitate review of this document.

Table 1 – List of System Acronyms

Acronym	Definition
ADS	Automatic Depressurization System
AISC	American Institute of Steel Construction
ANS	American National Standard
APRM	Average Power Range Monitor
ARTS	APRM/RBM/Technical Specifications
ASME	American Society of Mechanical Engineers
BPVC	Boiler and Pressure Vessel Code
BWR	Boiling Water Reactor
BWROG	BWR Owner's Group

Acronym	Definition
CDF	Cumulative Distribution Function
CDI	Continuum Dynamics, Inc.
CH	Pre or Post – LOCA Chugging
Cl 2	ASME BPVC Class 2 components
Cl 3	ASME BPVC Class 3 components
CO	Post-LOCA Condensation Oscillation
CS	Core Spray or Clam Shell (Modification)
D	Dead load
DBA	Design Basis Accident
DC	Downcomer
DE&S	Duke Engineering and Services
DISTRES	TES software application for shell stress analysis
DLF	Dynamic Load Factor
DW/DWT	Deadweight
EC	Event Combination or Engineering Change
ECCS	Emergency Core Cooling System
EQ	Earthquake
F	Peak stress per ASME BPVC
FB	Fall Back Load Condition (PS)
FEA	Finite Element Analysis
FEM	Finite Element Model
FFWTR	Final Feedwater Temperature Reduction
ft	Feet
GE	General Electric Company
GEH	General Electric Hitachi Company
GOTHIC	Heat transfer & two-phase flow software application
HPCI	High Pressure Coolant Injection System
IBA	Intermediate Break Accident

Acronym	Definition
IN	Information Notice
in	Inch
IR	Interaction Ratio
IWA	Integral Welded Attachments or Subsection of ASME SC XI Division 1 General Requirements
JAF	James A. FitzPatrick
JAF NPP	JAF Nuclear Power Plant
kips	1000 x lbf
ksi	Kips per square in
L	Live load
LAMB	GE DBA-LOCA mass & energy release software
lbf	Pounds force
lbm	Pounds mass
lbs	Pounds
LC	Load Condition
LDR	Load Definition Report
LOCA	Loss of Coolant Accident
Mat'l	Material
MC	Metal Containment
MEOD	Maximum Extended Operating Domain
Mk I	Mark I
MS	Margin of Safety
N	Normal Load
NO	Normal Operation
NPP	Nuclear Power Plant
NRC	US Nuclear Regulatory Commission
NUREG	US Nuclear Regulatory Commission Regulation
NYPA	New York Power Authority

Acronym	Definition
OBE	Operating Basis Earthquake
P	Pressure
P_A	Quasi-static accident pressure
P_B	Primary Bending Stress
PC	Primary Containment
P_{CH}	Post-LOCA Chugging Load
P_{CO}	Post-LOCA Condensation Oscillation Load
P_L	Primary Local Stress
P_M	Primary Membrane Stress
PNPS	Pilgrim Nuclear Power Station
P_{PS}	LOCA Pool Swell (DBA) Load
PS	LOCA Pool Swell (DBA) and Kinectrics designation for Torus Internal Pool Swell load at 1.7 ΔP PS NO
PS1	TES designation for 0.0 ΔP PS Accident Condition Load
PS2	TES designation for 1.7 ΔP PS NO Condition Load
PSI	Kinectrics designation for PS Inertia Load at 1.7 ΔP PS NO
PS0	Kinectrics designation for Torus Internal Pool Swell load at 0.0 ΔP PS Accident Conditions
PS0I	Kinectrics designation for PS Inertia Load at 0.0 ΔP PS Accident Conditions
PST	Total Dynamic Internal Plus External PS Load Condition
psi	Pounds per square inch
psi**a**	Pounds per square inch absolute
psi**d**	Pounds per square inch differential
psi**g**	Pounds per square inch gauge
PUAAG	Plant Unique Analysis Application Guide
PUAR	Plant Unique Analysis Report
PULD	Plant Unique Load Definition

Acronym	Definition
Q	Thermal Stress
QSTF	Quarter-Scale Test Facility
R_A	LOCA Reaction Load
RBM	Rod Block Monitor
RCIC	Reactor Core Isolation Cooling
RHR	Residual Heat Removal
RG	Ring Girder
RMS	Root Mean Square (i.e., SRSS)
R_O	Operating Reaction Load
RPV	Reactor Pressure Vessel
S	ASME BPVC Allowable Stress Value - SC III Subsections NC/ ND, Cl 2 & 3 Components B31.1 Power Piping
SBA	Small Break Accident
SC	Section of the ASME Code
sec	Seconds
SER	NRC Safety Evaluation Report
S_H	S at Design (Hot) Temperature
SLP	Stress due to Longitudinal Pressure
S_{MC}	ASME BPVC Allowable Stress Intensity Value - SC III Subsection NE Metal Containment
S_{M1}	ASME BPVC Allowable Stress Intensity Value - SC III Subsection NB Cl 1 Components
SRSS	Square-Root-Sum-of-the-Squares
SRV	Safety Relief Valve or Safety Relief Valve Discharge Load
SRVDL	Safety Relief Valve Discharge Line
SSCs	Systems, Structures & Components
SSE	Safe Shutdown Earthquake
S_U	Material Ultimate Strength

Acronym	Definition
Sx	Shell Element Normal Stress Component in the X-direction
Sxy	Shell Element Shear Stress Component on the X-Y plane
Sy	Shell Element Normal Stress Component in the Y-direction
S_Y	Material Yield Strength
T_A	LOCA Thermal Load
TAP	Torus Attached Piping
TES	Teledyne Engineering Services
TE	Thermal Expansion
TG	Torus Generic (calculation)
T_O	Operating Thermal Load
TR	Technical Report
UFSAR	Updated Final Safety Analysis Report
USAS	United States of America Standard
VCL	Vent Clearing Load Condition (PS Submerged Structure)
VH	Vent Header
VP	Vent Pipe
VY	Vermont Yankee Nuclear Power Plant
σ_x	Membrane Stress in the Longitudinal Direction
σ_θ	Membrane Stress in the Hoop Direction
$T_{x\theta}$	Shear Stress in the Longitudinal/ Hoop plane.

1.4 Terminology

The Mk I Program has a considerable vocabulary of terminology that was used circa 1980. A listing of some of the pertinent items has been prepared for reporting purposes to facilitate the user.

Table 2 - Terminology

Term	Description
Allowable Stress Intensity Value	The ASME Code SC II, Part D provides material properties including the Allowable Stress Intensity Values for PC Structural Element evaluation in accordance with SC III, Subsection NE, Division I [7.5.4].
Break Accident	Postulated pipe break inside the PC. Breaks are categorized according to size as Small (0.01 ft^2), Intermediate (0.1 ft^2) and Design with the Design Basis Accident resulting in a LOCA. The DBA is defined in the LDR as the instantaneous double-ended guillotine break of the recirculation pump suction line at the RPV nozzle [7.2.2, Section 2.0 Review of Phenomena].
Construction Code	The PUAAG was developed based on the 1977 Edition and Summer 1977 Addenda to SC III, Division 1 [7.2.1 Para. 1.3 Basis for Exception to this Guide & 7.5.1]. The NUREG-0661 Safety Evaluation prepared by the NRC approved the PUAAG Structural Acceptance Criteria [7.1.1]. Therefore, the original construction Code(s) were updated by the Mk I Program Structural Acceptance Criteria.
Dynamic Load Factor	The PUAAG Section 5, Component-Load-Service Limit Assignments, Table 5-1, Note 6 increases the allowable stress value, S_{MC} for the Structural Element evaluation of the PS cases [7.2.1]. S_{MC} may be multiplied by the DLF obtained from the computer model. The DLF is the difference between static application of the PS pressure distribution and the dynamic time-history application. The DLF was calculated in the Phase 1 Altran draft report as 1.228 [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0.0 ΔP].
Event Combinations	PUAAG Section 5 Component-Load-Service Limit Assignments, Table 5-1 lists 27 ECs composed of P, N, T_O or T_A, R_O or R_A, CO, CH, PS, SRV and OBE or SSE EQ Load Conditions involving SBA, IBA, DBA events to be evaluated for the Structural Elements [7.2.1].
Mk I - CH	As the RPV depressurizes, steam flow rate to the vent system decreases. Steam condensation during this period of reduced steam flow is characterized by movement of the water/ steam interface up and down within the downcomer as steam volumes are condensed and replaced by surrounding pool water [7.2.2, Section 4.5 Chugging Loads].

Term	Description
Mk I - CO	Following air carryover, there will be a period of high steam flow through the vent system. The discharge of steam into the pool and its subsequent condensation causes pool pressure oscillations which will be transmitted to submerged structures and the torus shell [7.2.2, Section 4.4 Condensation Oscillation Loads].
Mk I – LOCA Bubble	During the initial phase of the DBA, pressurized drywell air is purged into the suppression pool through the submerged downcomers. After vent clearing, a single bubble will form around each downcomer. During the bubble growth period unsteady fluid motion exposes submerged structures to transient hydrodynamic Vent Clearing Loads (VCL) [7.2.2, Section 4.3.8 LOCA Bubble – Induced Drag Loads on Submerged Structures].
Mk I – LOCA Jet	As the drywell pressurizes during the postulated LOCA the water slug initially standing in the submerged portion of each downcomer is accelerated downward into the suppression pool. As the water slug enters the pool, it forms a jet which could potentially load submerged structures which are intercepted by the Vent Clearing Load (VCL) discharge [7.2.2, Section 4.3.7 LOCA Jet Load].
Mk I - PS	The LDR describes this phase as covering the dynamic effects of the drywell and vent system air being forced through the vent system into the suppression pool to the wetwell airspace [7.2.2, Section 4.3 Pool Swell Loads].
Mk I - PS Bubble Phase	After the upward PS phase, the bubble pressure decreases as the bubble over expands and the pool liquid mass decelerates. Eventually, the bubbles “break-through” to the torus airspace and the displaced pool liquid settles back toward its original level [7.2.2 Section 4.3 Pool Swell Loads].
Mk I - PS Download Phase	In the postulated LOCA, the downcomer air, which is at essentially drywell pressure, is injected into the suppression pool, producing a downward reaction force on the torus [7.2.2, Section 4.3.1 Torus Net Vertical Load Histories].

Term	Description
Mk I - PS Froth Impingement Phase	Froth is an air-water mixture which rises above the pool surface and may impinge on the torus walls and structures within the torus airspace [7.2.2, Section 4.3.5 Froth Impingement Loads]. There are two mechanisms: Froth I – The rising pool strikes the bottom of the VH Deflector, froth is formed which travels upward and to the sides. Froth II – A portion of the water above the expanding air bubble becomes detached from the bulk pool and breaks into froth which rises into the air space beyond the maximum bulk pool height.
Mk I PS Inertia	The inertia loads are a result of the Torus Shell response (motion) resulting from the PS Load Condition. The inertia loads are input to the TAP at the Torus Penetration.
Mk I - PS Pool Fallback (FB)	Following the pool swell transient, the pool water falls back under the influence of gravity to its original level and in the process generates fallback (drag) loads between the bulk pool height and the downcomer exit [7.2.2, Section 4.3.6 Pool Fallback Loads].
Mk I - PS Upload Phase	After the completion of the downward PS phase the consequent bubble expansion causes the pool water to swell in the torus, compressing the airspace above the pool and producing the upward reaction force on the torus [7.2.2, Section 4.3.1 Torus Net Vertical Load Histories].
Mk I - PS Vent System and Structures Impact and Drag	As the pool surface rises, it impacts structures in its path. The impact consists of two events, the impact of the pool on the structure, and the drag on the structure as the pool flows past [7.2.2, Section 4.3.4 Impact and Drag on Other Structures Above the Pool].
Mk I - Vent System Thrust	Following the DBA, the drywell pressure increases and the water initially occupying the submerged portion of the vent system is accelerated into the pool, clearing the vents. Following vent clearing, there is a period during which bubble formation and break through occurs. Mass flow rates and velocities in the vent system become significant along with momentum load [7.2.2, Section 4.2 Vent System Thrust Loads].
Reconciliation	The process of evaluating and justifying use of alternative Construction Code requirements or revised Owner's Requirements [7.5.6, Article IWA-0900, Glossary]

Term	Description
Service Level	The ASME Code categorizes service load conditions which the structural element may be subjected to into 4 operational categories: 1. A – Normal – the conditions of startup, hot standby, operation within the normal power range, and cooldown and shutdown of the plant. 2. B – Upset – Those deviations from the normal plant condition which have a high probability of occurrence. 3. C – Emergency – Those operating conditions which have a low probability of occurrence. 4. D – Faulted – those operating conditions associated with extremely low probability postulated events. These are discussed in the PUAAG [7.2.1, Section 4.0 Design and Service Limits]
Service Load Conditions	PUAAG Section 5, Component-Load-Service Limit Assignments, Table 5-1 lists the Load Conditions as N, EQ, SRV, T_A, R_A, P_A, P_{PS}, P_{CO} and P_{CH} [7.2.1].
SRV Blowdown Phase	Prior to initial actuation of the SRV caused by a normal operational transient, the SRV discharge lines contain air and suppression pool water in the submerged portion of the SRVDL. Water level is dependent on the drywell to wetwell differential pressure (psi**d**). Following actuation steam enters the SRVDL compressing the air and expelling the water slug into the suppression pool. The SRVDL undergoes transient pressure load [7.2.2, Section 2.4 Safety/ Relief Valve Actuation].
SRV Bubble Phase	Once the water has cleared from the T-Quencher upon SRV actuation, the compressed air enters the pool in the form of high-pressure bubbles. The bubbles expand resulting in an outward acceleration of the surrounding pool water load [7.2.2, Section 2.4 Safety/ Relief Valve Actuation].
SRV Jet Phase	Post SRV actuation the water jet exiting from the T-Quencher enters the pool resulting in drag loads on the submerged structures within the influence of the jets loads [7.2.2, Section 2.4 Safety/ Relief Valve Actuation].
SRV T-Quencher	SRVDL device/ structural element submerged under the suppression pool at the end of the line employed in Mk I plants [7.2.2, Section 1.1 Description of the Mark I Containment & Figure 1.1-4].

Term	Description
Steam Condensation	The LDR describes this portion of the dynamic event during the period following initial air clearing when the flow into the suppression pool is a steam – air mixture. The steam is condensed at the downcomer exit while the air rises through the pool to the wetwell airspace [7.2.2, Section 2.1 Design Basis Accident].
Stress Intensity	Twice the maximum shear stress which is the difference between the algebraically largest principal stress and the algebraically smallest principal stress at a given point [7.5.1 & 7.5.2 Para. NE-3215, Derivation of Stress Intensities].
Structural Elements	The torus shell and supports, external vents and vent-to-torus bellows, drywell-vent connections, internal vents, vent ring header and supports, attached internal and external piping systems with active/ inactive components and supports, torus internal structures and VH deflector as defined by the PUAAG Section 5, Component-Load-Service Limit Assignments, Table 5-1 [7.2.1]. While the Torus Attached Piping is also listed in Table 5-2 as additional Structural Elements the Mk I Program generally describes the TAP separately from the other Structural Elements.
Submergence	Submergence is referenced from the bottom dead center of the torus ID to the water level. Currently JAF submergence is 14.0 Ft. Submergence (Downcomer) is the measure of water level upward from the tip of the downcomer. Current JAF downcomer submergence is 50 inches or 4.17 Ft. Submergence (QSTF) is a scaling parameter based on the Quarter Scale Test Facility results and measured as the downcomer submergence of 50 inches divided by 4 or 12.5 in.
Torus Attached Piping	Internal and External Cl 2 and Cl 3 piping systems attached to the Torus requiring evaluation for the Event Combinations as outlined in the PUAAG Section 5, Component-Load-Service Limit Assignments, Table 5-2 [7.2.1].
Cl 2 or Cl 3 Piping System	Piping which is contained within the Vents or Torus and Main Steam SRV piping contained within the Torus, Drywell or External Vents are Class 2 or Class 3 [7.2.1, Section 2.2.12 Internal Piping and Supports].

Term	Description
Non-Essential Piping Systems	Piping that is not required to perform a safety-related role during an event combination [7.2.1, Section 2.2.8 Essential and Nonessential Piping Systems].
Essential Piping Systems	A system or portion of a piping system that is necessary to assure: a. The integrity of the reactor coolant pressure boundary, b. The capability to shut down the reactor and maintain it in a safe shutdown condition, or c. The capability to prevent or mitigate the consequences of accidents [7.2.1, Section 2.2.8 Essential and Nonessential Piping Systems].

2.0 INPUT INFORMATION AND ASSUMPTIONS

There are several significant inputs required to perform the analysis for the Torus, Torus Supports, Vent System, VH Supports, VH Deflector, SRV T-Quencher and Internal Structures.

2.1 Metal Temperature for PS Evaluation

Metal temperature at the start of the postulated LOCA PS event is < 110^{0}F per Technical Specification [7.6.2 Para. No. 3.6.2.1]. The Mk I Program used an initial suppression pool temperature of 77.5^{0}F [7.2.2, Section 4.1.1 Design Break Accident, Table 4.1.1-3]. The metal temperature at the end of the PS event which is approximately 1.5 sec in duration per LDR Figure 3.0-1 will be in the same range. The structure and water mass cannot respond that rapidly.

2.2 Bounding SRV Evaluation

The PUAR discusses the bounding "worst case" SRV Load Condition as an A-1.2 SBA/IBA first actuation combined with a C3.3 SBA/IBA reflood case (Steam enters through the Vacuum Breaker Valve in the Drywell with condensation causing a High Reflood) which was the single analyzed case; [7.3.3, Section 2.0 SRV Piping Loads]. As discussed in PUAR Table 2-1 per Note (1) the DBA case post-PS A-1.3 does not contain enough energy to actuate a valve. This combined SRV Load Condition was used for all analysis.

The shell stress analysis validation in TG-8 was reviewed and the SRV stresses for all ECs were consistent indicating that one bounding load condition was used for the evaluation [7.4.2, Section IV Pages 37 & 38].

2.3 PS Fatigue Evaluation Requirements

Per the ASME BPVC SC III Subsection NE (Figure NE-3221-3 & 4) and the PUAAG (Table 5-1, Note 3) the DBA ECs which involve PS and are Code Service Level C or D need not consider combined primary plus secondary stress range ($P_L + P_B + Q$) or Fatigue ($P_L + P_B + Q + F$) [7.5.2 & 7.2.1, Section NE-3221.5 Analysis for Cyclic Operation]. PS ECs 16 & 18 are Service Level A & B, respectively. The PUAAG recognized that PS is Quasi Static and occurs as a single stress range cycle on the structural elements and therefore need not be considered with respect to fatigue.

2.4 Event Combinations with SRV and EQ

The SRV and EQ load conditions may be SRSS'd per Section 2.4.2 of the TAP Teledyne Report [7.3.3]. The Mk I Program determined that the probability of peak load from these two Load Conditions coinciding was very small. This is consistent with the PUAAG which discusses the use of a CDF if the absolute sum method does not satisfy the Structural Acceptance Criteria [7.2.1 Para. 6.3b]. In addition, the PUAR also indicates that in a few cases, seismic results were SRSS'd with other dynamic loads; Appendix 4 NRC Review Comments and Responses, Pages A4.2-36 & 43 [7.3.2]

2.5 FEM Refinement - TES 1/32nd vs. Altran 1/16th

The TES Torus shell stress model was a 1/32nd segment [7.3.2]. The refined Altran Torus shell stress model is a 1/16th segment [7.3.4]. The boundary conditions on the TES model with respect to the shell approximate a cantilever beam structure fixed in the plane of the RG/ saddle/ columns. The 1/16th model also included refinement with respect to the torus column flange plate configuration. The refined boundary conditions on the Altran model approximate a multiple span structure with a simple support at the RG/ saddle/ columns. Therefore, the expectation is that shell stress intensity will be refined on the Altran model and that there will be some load redistribution on the Torus Support System for the same load conditions due to the added model refinements.

Based on a review of the primary membrane and bending shell stress intensity results from the 1/16th model compare well with the 1/32nd model. Loading was shown to redistribute with increased column loading and decreased saddle loading in the support system. Therefore, due to the 1/16th model refinement with respect to the torus column; 1/16th model support loads for the column and saddle were used for the evaluation.

2.6 PS DLF

The PS DLF is discussed in Section 2.10.13 this report. The value is 1.228. Per Note (6) of Table 5-1 of the PUAAG for the Torus Shell the Allowable Stress Value of S_{MC} may be replaced by DLF x S_{MC} to better predict the margin on failure stress [7.2.1].

2.7 Determination of Torus Shell Stress for Individual Load Conditions

The final reported shell stress results do not provide the individual load condition stress information for all ECs [7.3.2, Section 3.3.1, Torus Shell]. However, they can be obtained from the DISTRES computer output discussed in Section 2.9. The two controlling JAF ECs are 14 and 20. These ECs control based on CO load conditions.

The DISTRES output contains the individual shell element top/ middle/ bottom stress components (Sx, Sy & Sxy) for all the analyzed load conditions. Therefore, P_M and P_L + P_B stress intensities necessary for the bounding PS cases of Section [2.10] can be assembled. The individual stress components can be adjusted as detailed in Table 13 with new stress intensity values calculated.

The Altran 1/16th model was not post-processed during the initial phase to obtain PS stress results on the elemental level as the goal was to obtain refined stress results in the weld joints due to the refinements discussed in Section 2.5.

2.8 Corrosion Allowance

As described in the FitzPatrick Torus Corrosion Allowance calculation; during the Mk I Program it was determined in the best interest of the plants to use the available torus shell thickness 0.632 in without consideration of the Design corrosion allowance to provide more margin in support of the Hydrodynamic load conditions [7.4.19]. The torus shell was coated with a zinc rich protective coating reducing the corrosion rate considerably. Post Mk I Program JAF revisited the corrosion allowance issue and decided to use 0.489 in for the nominal shell thickness providing a corrosion allowance of 0.143 in. for a full shell thickness of 0.632 in. As a result, torus shell stress intensity was increased by a factor of 1.2924 (0.632/0.489) as stress intensity is proportional to the shell thickness. The Torus Corrosion Allowance calculation provided Event Combination stress results that were adjusted for the corrosion allowance [7.4.19]. This calculation also addresses the subsequent 1998 ECCS Suction Strainer update and current R23 Clamshell modification. Details addressed by the FitzPatrick Torus Corrosion Allowance calculation are as follows [7.4.19]:

1. The 1998 ECCS Suction Strainer update to increase capacity was designed and installed for all the ECCS and the RCIC suction strainers and it was concluded that the larger strainers increased the torus shell stress intensity P_M by an additional 1347 psi away from the ring girder.
2. In addition, the 1998 ECCS strainer update increased shell stress intensity local to the strainer attachment points, Kinectrics' Calculation A384.F02-15 Section 5.0 Summary and Conclusions had limited the corrosion allowance on the lower half of the shell to 0.100 inch as discussed in Section 2.17.2 [7.4.64].

The conclusion of the FitzPatrick Torus Corrosion Allowance calculation is that the lower shell corrosion allowance of 0.143 inch is an acceptable limit. Therefore, the 0.143 in shell thickness is valid for the entire torus shell.

2.9 DISTRES Information

The DISTRES program calculated the Mk I Torus shell stress intensity results for all the ECs and provided them in final table of bounding ECs [7.4.2].

1) A review of the tabulated SRV stress results on a per element basis for all SRV ECs indicates that only one "worst case" SRV Load Condition was used. The program did have the ability to factor the SRV Load Condition but the default value of 1.0 was used [7.4.2, Section IV Method of Analysis, Pages 37 & 38 and 7.4.18, Input Data Page 4]. The combined A-1.2 and C3.3 Case discussed in Section 2.2 was used.
2) Based on a review of the tabulated stress results both the 1.7 ∆P and the 0.0 ∆P Load Conditions were considered in the evaluation, [7.4.2, Section IV Method of Analysis, Pages 42 – 45].
3) The "DISTRES Program Check" contains a project memorandum that discusses the fact that the remaining RPV pressure post-DBA PS is not sufficient to actuate an SRV [7.4.2, Appendix D Memoranda, Page 206]. Therefore CO/CH ECs 23, 26 and 27 with SRV need not be evaluated.
4) The actual "DISTRES" run A3OTBRT, June 1982 for JAF contains component stress results for each load condition [7.4.18].

2.10 Load Condition Adjustment Factors

The normal operating condition using 0.0 ∆P versus 1.7 ∆P differential pressure between the drywell and wetwell requires that affected load conditions be evaluated along with any Post Mk I Program modifications to the Torus. In addition, a proposed change of +3 inches in submergence (i.e., torus water level) and completion of the proposed 3-Stage SRV replacements shall also be considered. The final load condition adjustments described in detail below are summarized in Table 13 - Load Condition Adjustment Factors for Structural Element Evaluation and Table 14 - Load Condition Adjustment Factors for +3" Increased Submergence.

2.10.1 Vent System Thrust

The Vent System Thrust load was generally analyzed by TES for the 1.7 ∆P case because the CO load controlled by a significant magnitude (i.e., a factor of 2 or more). Therefore, the 0.0 ∆P thrust load was not analyzed with the higher Service Level D allowable because it was not of concern.

The VH/VP intersection analysis in TES Calculation 2386-8 provides the Vent System Thrust Loads used in the evaluation [7.4.9, Thrust Loads Page 7].

Table 3 below, compares the Vent System Thrust Load provided in the PULD to the values used in TES Calculation 2386-8. It demonstrates that there is very little difference between the 1.7 ∆P and the 0.0 ∆P load for a bay of the Vent System. That is, the differences are within the accuracy of the analysis. However, it is clear from the review that the Calculation used the 1.7 ∆P values.

While the difference between the two cases is small when combined for the entire vent system the change in the maximum Net Vertical Load is on the order of 5% (525/500-1) corresponding to a Load Condition adjustment factor of 1.05. There is no discussion about an adjustment factor for the number of tests. However, it is appropriate to use the same factor as developed in Section 2.10.2 for the 0.0 ∆P PS ↓ Download Phase of 1.11.

Table 3 - Vent System Thrust Load from PUAR

Thrust Load Direction (1)	1.7 ∆P Force kips	Time sec	PULD Figure	0.0 ∆P Force kips	Time sec	PULD Figure	(2) TES Calc. 2386-8
F1V1	-50	1.3	F 4.2-2	-50	1.3	F 4.2-12	-50
F1H1	-134	1.3	F 4.2-2	-140	1.3	F 4.2-12	-134
F2V	50	1.3	F 4.2-3	55	1.3	F 4.2-13	50
F2H	20.5	1.3	F 4.2-3	20.5	1.3	F 4.2-13	20.5
F3V	0.9	1.3	F 4.2-4	1.0	1.3	F 4.2-14	1.0
F3H	-3.5	0.4	F 4.2-4	-3.9	0.4	F 4.2-14	-4.1
FNETV	500	1.3	F 4.2-5	525	1.3	F 4.2-15	Not Used

Table Notes:

1. Figure for Thrust Direction [7.2.4]
2. 2386-8 [7.4.9, Thrust Loads Page 7]

The Adjustment Factor applied to the original 1.7 ∆P Vent System Thrust to estimate 0.0 ∆P Vent System Thrust is 1.05.

Adjustment Factor applied to the original 0.0 ∆P Vent System Thrust for Normal Operation is: 1.11

2.10.2 0.0 ∆P ↓ Mk I PS Download Phase Pressure Adjustment

The PS ↓ Download Phase maximum shell pressure adjustment is provided in Altran Draft TR 13-0541-TR-001 [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0ΔP]. The maximum 0.0 ΔP ↓ pressure @ .295 seconds into the PS Event which is composed of the average submerged pressure with applicable test correction factor and torus airspace pressure is 14.54 psi [7.4.4, Section VI C FitzPatrick PRESDIG Output, Page 55]. This was the methodology used during the Mk I Program when the 0.0 ΔP Event Combination 16 was considered to be an accident condition with Service Level D (Faulted) Allowable Stress Values per Note (1) of the PUAAG [7.2.1, Section 5 Component-Load-Service Limit Assignments, Table 5-1].

Given that the 0.0 ΔP ↓ Load Condition will be the normal operating condition for JAF, the Altran Draft TR 13-0541-TR-001 (Attachment 1) makes an additional adjustment recognizing that there was only one Quarter Scale Test performed @ 0ΔP. The adjusted pressure is 16.17 psi [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0ΔP].

Using the PRESDIG pressure results for JAF the 1.7 ΔP ↓ PS Download pressure is 6.29 psi [7.4.4 Section VI-C, FitzPatrick PRESDIG Output, Page 50]. Therefore, to convert shell stress and support loads from 1.7 ΔP ↓ to 0.0 ΔP ↓ the factor is 2.31 (14.54/ 6.29).

The Adjustment Factor applied to the original 1.7 ΔP ↓ PS Download Phase to estimate 0.0 ΔP ↓ PS Download Phase is 2.31.

Adjustment Factor applied to the original 0.0 ΔP ↓ PS Download Phase for Normal Operation is: 1.11 (16.17/ 14.54).

2.10.3 0.0 ΔP ↑ Mk I PS Upload Phase Pressure Adjustment

The PS ↑ Upload Phase maximum shell pressure adjustment is provided in the Altran Draft TR 13-0541-TR-001 [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0ΔP]. The maximum 0.0 ΔP ↑ pressure @ .600 seconds into the PS Event with applicable test correction factor is 7.29 psi [7.4.4, Section VI C, FitzPatrick PRESDIG Output, Page 55]. This was the methodology used during the Mk I Program when the 0.0 ΔP Event Combination 16 was considered to be an accident condition with Service Level D (Faulted) Allowable Stress Values per Note (1) of the PUAAG [7.2.1, Section 5 Component-Load-Service Limit Assignments, Table 5-1].

Given that the 0.0 ΔP ↑ Load Condition will be the normal operating condition for JAF, the TR 13-0541-TR-001 (Attachment 1) makes an additional adjustment recognizing that there was only one Quarter Scale Test performed @ 0ΔP. The adjusted pressure is 7.68 psi [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0ΔP].

Using the PRESDIG pressure results for JAF the 1.7 ΔP ↑ Upload pressure is 4.62 psi [7.4.4, Section VIC PRESDIG Output, Page 50 of 175]. Therefore, to convert shell stress and support loads from 1.7 ΔP ↑ to 0.0 ΔP ↑ the factor is 1.58 (7.29/ 4.62).

The Adjustment Factor applied to the original 1.7 ΔP ↑ PS Upload Phase to estimate 0.0 ΔP ↑ PS Upload Phase is 1.58.

Adjustment Factor applied to the original 0.0 ΔP PS ↑ Upload Phase is: 1.05 (7.68/ 7.29).

2.10.4 0.0 ΔP Mk I LOCA Jet & Bubble

While most submerged structures were evaluated for LOCA Jet & Bubble loads at the 0.0 ΔP load condition it may be necessary to determine a factor for the 1.7 ΔP load condition. The VH columns are submerged local to the downcomers and are a representative geometry with respect to the two LOCA loads. TES evaluated the columns and reported results as follows:

Table 4 - LOCA Loads – Vent Header Support Analysis

LOCA Forces VH Column	LOCA BUBBLE 1.7 ΔP lbs/in @ sec	LOCA BUBBLE 0.0 ΔP lbs/in @ sec	LOCA JET 0.0 ΔP lbs/in @ sec
Inner Column	241.6 @ 0.0680	491.9 @ 0.0280	751.8 @ 0.3617
Outer Column	128.9 @ 0.0580	270.2 @ 0.0220	264.1 @ 0.3225

Table Notes:

1. The evaluation did not report 1.7 ΔP LOCA JET nor did it reference a computer run for it [7.4.7, Drag Loads, Pages 7 to 15].
2. Based on the VH column loads reported the factor from 1.7 to 0.0 ΔP is 2.1 (491.9/241.6 and 270.2/128.9) for the LOCA Bubble Load Condition. The results compare well with the PRESDIG shell pressures in Section 2.10.2.

Table 5 - PS Maximum Shell Pressure

PS Load Condition	Pressure psi	Time sec
1.7 ΔP	6.28	.202
0.0 ΔP	14.54	.295

The results provide a static factor of 2.32 (14.54/ 6.28). Imperia concludes that a factor of 2.1 based on the local LOCA Bubble loads shall be used on the 1.7 ΔP results to determine the 0.0 ΔP results for the LOCA Jet and Bubble Loads where necessary. Note that there is no documentation that a test factor need be applied for the LOCA Jet and Bubble Loads at 0.0 ΔP to account for number of QSTF tests.

Adjustment Factor applied to the original 1.7 ΔP LOCA Jet and/or Bubble Load to estimate 0.0 ΔP contribution is: 2.10 as described above.

Adjustment Factor applied to the original 0.0 ΔP LOCA Jet and/or Bubble Load is 1.0.

2.10.5 0.0 ΔP Mk I Impact and Drag

Impact and Drag loads are imposed on the Vent System and above the pool structures as the pool rises. Adjustment factors calculated for the VH based on impact pressure will be used for those above the pool structures as well.

VH impact pressure at both 1.7 ∆P and 0.0 ∆P are contained in the JAF PULD [7.2.4, Tables F 4.3.3-1 & 2]. Most of the Mk I Program analysis was completed using 0.0 ∆P loads for Vent System Impact and Drag. However, a few cases did not. For those cases, the increased loads for 0.0 ∆P based on a comparison of the average impact pressure on the vent system are as follows:

1.7 ∆P

(9.17 + 4.43 + 1.29 + 6.21 + 4.44 + 0.74 + 8.31 + 9.89 + 3.52 + 7.24 + 11.75 + 5.37 + 6.96)/ 13 = 6.10 psi

0.0 ∆P

(15.40 + 3.47 + 3.17 + 6.27 + 2.40 + 1.24 + 11.49 + 8.93 + 6.02 + 8.70 + 15.02 + 5.86 + 9.34)/ 13 = 7.49 psi

The average increase is therefore 1.23 (7.49/ 6.10).

While there is no mention in the Mk I Program LDR or SER of a statistical adjustment for only one Vent System Impact and Drag test at 0.0 ∆P it is prudent to use the 0.0 ∆P ↑ Upward Phase adjustment developed in the Altran Phase 1 Draft TR 13-0541-TR-001 of 1.05 [7.3.4].

Total Adjustment is 1.23 x 1.05 = 1.29.

Adjustment Factor applied to the original 1.7 ∆P Vent System Impact and Drag Load Condition to estimate 0.0 ∆P contribution is 1.23 as described above.

Adjustment Factor applied to the original 0.0 ∆P Impact and Drag is 1.05.

2.10.6 0.0 ∆P Mk I - PS Froth Impingement Phase

Froth is defined by the LDR as a mixture of water and air that affects the structures above the pool [Section 1.4 Table 2 - Terminology]. The Froth Region I load occurs as a result of pool impact with the VH and/or the VH deflector and Froth Region II results from air bubble breakthrough when the pool is at its maximum height. Both Froth Regions I and II are related to the square of the pool upward velocity. Froth I at the time of VH or VH Deflector impact and Froth II at the maximum pool height prior to fallback. These velocities are available from the QSTF testing at both 1.7 ∆P and 0.0 ∆P [7.2.5].

Froth Region I

The Froth Region I load results from impact with the VH Deflector. The load is related to the square of the velocity of the rising pool at the time of VH Deflector impact. Note that Froth I impact zone is defined in the LDR Figure 4.3.5-1 as 45^0 below the horizontal center line of the vent header upward and to the side, shielded by the vent header. Therefore, the impact zone selected for the velocity comparison would correspond to the 12" from centerline test dimension where the pool continues to rise upward upon impact.

QSTF results for Velocity at the bottom of the VH are given in Figures A-757 on Page A-844 and Figure A-759 on Page A-846. Based on Table 6 the adjustment factor from 1.7 ∆P to 0.0 ∆P Accident is a 0.84 (256.0/306.3) reduction. However, for reporting purposes the factor used will be 1.0 for Froth Region I. Based on the discussion a reduction would also apply for 0.0 ∆P NO.

Table 6 - QSTF Pool Velocity for Froth Region I

∆P	VH Centerline Location in	Time sec	Maximum Velocity ft/ sec	Velocity^2 ft^2/ sec^2
1.7	12	0.175	17.5	306.3
0.0	12	0.250	16.0	256.0

Adjustment Factor applied to the original 1.7 ∆P Froth Impingement Region I Load Condition to estimate 0.0 ∆P Accident and NO contributions is: 1.0 as described above.

Froth Region II

Froth Region II loads result from air bubble break through above the pool at maximum height. The load is related to the square of the velocity but at maximum pool height.

QSTF results for pool height and velocity are given on Figures A-752 (Test 1), A-753 (Test 2), A-754 (Test 3), A-756 (Tests 1, 2 &3) and A-757 (Tests 1, 2 &3) for 1.7 ∆P and A-755 (Test 5), A-758 (Test 5) and A-759 (Test 5) for 0.0 ∆P. Based on Table 7, the adjustment factor from 1.7 ∆P to 0.0 ∆P is a 0.68 (144/ 210.3) reduction. However, for reporting purposes the factor used will be 1.0 for Froth Region II. Based on the discussion a reduction would also apply for 0.0 ∆P NO.

Table 7 - QSTF Pool Velocity for Froth Region II

∆P	VH Centerline Location in	Maximum Pool Height in	Maximum Velocity ft/ sec	Velocity^2 ft^2 /sec^2
1.7	18	20.5	14.5	210.3
0.0	24	20.5	12	144.0

Adjustment Factor applied to the original 1.7 ∆P Froth Impingement Region II Load Condition to estimate 0.0 ∆P Accident and NO contributions is: 1.0 as described above.

2.10.7 0.0 ∆P Mk I – PS Fallback

Pool Fallback only affects the ECCS suction strainers. The original calculations with accompanying revisions are documented in References 7.4.20, 7.4.21 and 7.4.22. Reference 7.4.20 contains the strainer Hydrodynamic Load Evaluation. The PS fallback loads are discussed in Sections 11 and 14 of the calculation.

The Strainers are shown in Figure 8.1 to the outer column side of the torus in the area between the outside VH downcomer and the torus shell [7.4.20]. Based on QSTF as reported on Figures A-756 and A-758, the maximum pool height which controls fallback load is 20.5 in for both the 1.7 and 0.0 ∆P PS Accident and NO cases [7.2.5]. If we look at an average of the two locations 18 and 24 the pool height is 20 in for both 1.7 $(\left(\frac{20.5+19.5}{2}\right) = 20)$ and 0.0 $(\left(\frac{19.0+20.5}{2}\right) = 19.75)$ ∆P. Therefore, it can be concluded that the PS Fallback load is insensitive to submergence and does not require adjustment from 1.7 to 0.0 ∆P.

Adjustment Factor applied to the original 1.7 ∆P PS Fallback Load Condition to estimate 0.0 ∆P Accident and NO contributions is: 1.0 as described above.

2.10.8 0.0 ∆P & +3-inch Submergence SRV Jet & Bubble Phase

2.10.8.1 Bubble Drag

The original TES PUAR published the results of SRV Discharge testing [7.3.2, Appendix 1]. The results of the testing provided the combined SRV Drag as an equivalent static pressure on submerged structures. The information used to develop the drag loads was taken from all five plants in the TES Program. TES determined that the bubble drag equivalent pressures were a function of distance from the T-Quencher and that the pressure is independent of submergence.

The LDR describes the Bubble Drag Load as a function of the pressure at the Air/ Water interface (i.e., bubble charging pressure) which is a function of the Main Steam Line pressure and not submergence [7.2.2, Section 5.2.1.1 c. S/RV Air Bubble Charging Pressure]. Therefore, it is concluded that the SRV Bubble Drag will not change with submergence due to 0.0 ∆P or the proposed 3-inch increase in maximum submergence from 50 to 53 inches.

Adjustment Factor applied to the original 0.0 ∆P SRV Bubble Drag Load to accommodate added submergence is: 1.0 as described above.

2.10.8.2 Jet Loads

The Jet Loads are a function of the submergence. At 0.0 ∆P with additional 3-inch submergence the jet loads would be larger in magnitude due to the increased water leg which would result in higher velocity before clearing is completed. However, based on the Mk I Program testing Teledyne concluded that the Jet Loads were significantly smaller than the Bubble Loads. This is evident because both Jet and Bubble Drag were both considered in the preparation of the PUAR Figure A1-5 using data from the 5 plants [7.3.2]. Each plant was tested individually at its plant unique submergence. The figure does not require a submergence factor to be applied for structures in the jet path. It is concluded that adjustment of the Jet Loads need not be considered as they are bounded by the Bubble Loads.

Adjustment Factor applied to the original 0.0 ∆P SRV Jet Load to accommodate added submergence is: 1.0 as described above.

2.10.9 Post Mk I Program - 4.1% Thermal Power Uprate and ARTS/ MEOD Power Uprate

GE prepared two documents for power uprate to the plant; The first for the original 4.1 % thermal power uprate NEDC-32016P-1 and the second for the ARTS/ MEOD uprate NEDC-33087P [7.2.7 & 7.2.8].

Altran Draft Technical Report 13-0541-TR-001 reviewed the effect of the thermal power uprate on the PS Download and Upload Phases on shell pressures. It was concluded that any increases were smaller than conservatisms in the computer codes used in the calculation [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0ΔP].

The Altran Draft Technical Report also concluded that the effect of the thermal power uprate on SRV discharge load into the Torus is smaller than conservatisms in the computer codes.

GE also concluded in Section 4.1.2.1, Page 4-4 of NEDC-32016P-1 that; "the LOCA dynamic design loads are not impacted by power uprate" [7.2.8]. Clarifying that "the LOCA containment dynamic loads analysis for power uprate is based primarily on the short-term LOCA analyses……. The short-term containment response conditions with power uprate are within the range of test conditions used to define the pool swell and condensation oscillation design loads for the plant."

GE concluded in Section 9.4, Page 9-9 of NEDC-33087P that; "MEOD including operation with FFWTR does not result in an increase in the peak DBA-LOCA drywell pressure nor result in conditions that would produce higher LOCA hydrodynamic loads" [7.2.7]. Further the conclusion references the TES Technical Report TR-5321-1 and states that "the results of the containment loads evaluation….... remain within their defined values" [7.3.2].

Based on Imperia's review of the reference documents it is concluded that the JAF power uprates do not affect the Mk I Program DBA LOCA loads.

Adjustment Factor applied to the original 0.0 ΔP PS load to accommodate the 4.1% Thermal Power Uprate and ARTS/ MEOD Uprate is: 1.0 as described above.

2.10.10 Post Mk I Program - Water in Vent Pipe Bowl

The historical issue with water in the vent pipe bowls is discussed in Section 2.15 of this report. It has been concluded that the timing of the increased (6.2%) thrust load does not correspond to the peak event load and therefore the increased thrust load need not be considered.

Adjustment Factor applied to the original 0.0 ΔP PS load to accommodate the Water in the Vent Pipe is: 1.0 as described above.

2.10.11 Post Mk I Program - 3-Stage SRV Replacements

JAF proposed an SRV upgrade from 2-Stage to 3 Stage valves as described in EC 14122 which modified the first three SRVs [7.4.6]. Subsequent to implementation of this successful modification all 11 SRVs were replaced.

Post Mk I Program JAF proposed new 3-Stage Target Rock SRVs at all locations with the same set point (1145 psig) and opening times as the 2-Stage SRVs. However, the initial EC 14122 was written to install the SRVs at 3 trial locations. The new valves have a 5.125-inch throat increased from 5.03 inches. The set point of 1145 psig remains the same. Therefore, the mass flow rate will increase (291 vs 311 lbm/sec). The results of the EC evaluation are described in the EC 14122 Topic Notes Narrative Section 3.1.21, "Mark I Loads Evaluation." It was concluded that the modification was acceptable.

It was also concluded for the Torus Shell, Submerged Structures, and TAP that the baseline Jet and Bubble Drag values from the original SRV analysis of record bounded the new results due to an error in the original Mk I Program Code RVFOR-

04 that was later corrected in RVFOR-05 which EC 14122 concluded was not used by TES due to late timing of the revision. Imperia has validated that RVFOR-04 was used [7.3.3, Section 2.2.1 SRV Gas Clearing Loads].

Adjustment Factor applied to the original 0.0 ∆P PS load to accommodate the new 3-Stage Target Rock SRVs at all locations is: 1.0 as described above.

2.10.12 Post Mk I Program - Plus Three-Inch Submergence Increase (50 to 53 inches)

Vent Header Thrust

At 0.0 ∆P the downcomer clearing velocity is 31 ft/sec at 0.142 sec [7.2.6, Figure A-762]. A 3 in increase in the submergence changes the downcomer clearing time by .008 sec (3/12 ft. x 1/31 sec/ft.) or 5.6%.

Adjustment Factor applied to the original 0.0 ∆P PS load to accommodate the Vent Header Thrust for the +3-inch submergence is 1.056.

PS ↓ Download Phase

The proposed 2-inch submergence increase on the PS ↓ Download Phase is 2.6% as detailed in Altran Draft Technical Report 13-0541-TR-001 [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0.0 ∆P]. This is a linear calculation based on the reference information. Therefore a +3” submergence increase would be 3.9%.

Adjustment Factor applied to the original 0.0 ∆P PS load to accommodate the PS Download Phase for the +3-inch submergence is 1.039.

PS ↑ Upload Phase

The proposed 2-inch submergence increase on the PS ↑ Upload Phase is -2.1% as detailed in Altran Draft Technical Report 13-0541-TR-001 [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0.0 ∆P]. This is a linear calculation based on the reference information. Therefore a +3” submergence increase would be -3.2%.

Adjustment Factor applied to the original 0.0 ∆P PS load to accommodate the PS Upload Phase for the +3-inch submergence is 0.968.

SRV DLs

As discussed in Section 2.2, TES concluded that SRV Case A1.2 was bounding for the gas clearing loads and that the maximum SRVDL reflood and water clearing loads are associated with SRV C3.3. A1.2 is a first actuation after an SBA/IBA which is characterized by an increase gas density in the SRVDL due to increasing drywell pressure. The increased density produces higher thrust forces. C3.3 is a second actuation after an SBA/ IBA with steam in the drywell and produces the highest reflood because of steam entering the SRVDL through the vacuum breakers (rather than air) after the first actuation.

The 3” submergence increase is also not significant with respect to the SRVDL Submerged Structure Jet and Bubble Drag Load because the original analysis used a bounding combination of the A1.2 along with the C3.3 high-reflood. This is further discussed in Section 2.10.8.

Adjustment Factor applied to the original SRV DL load to accommodate the +3-inch submergence is 1.0.

Vent Header and Above the Pool Structures Impact and Drag

The effect of the 3-inch increase in submergence can be calculated from the QSTF results [7.2.3, Figure 3-52]. Using the quarter scale VH Impact Force with the increase in submergence from 50 to 53 inches (i.e., 12.5 to 13.25 inches in quarter scale) the percent change in impulse force can be calculated from Figure 3-52 Sensitivity of VH impact force Impulse to Downcomer Submergence:

$$Percent\ Impulse\ Force\ Increase = \frac{8.1 - 7.8}{7.8} = 3.9\%$$

Adjustment Factor applied to the original 0.0 ∆P PS load to accommodate the Vent Header and Above Pool Structures Impact and Drag the +3-inch submergence is 1.039.

LOCA Bubble and Jet

The LOCA Bubble and Jet Load conditions are vent clearing phenomena. The jet load results from the accelerated water slug clearing the downcomer followed by purged drywell air which results in bubble formation around each downcomer.

The increase in loading due to the increased 3 in submergence can therefore be related to the increase in vent header thrust loading which can be derived from mass and momentum equations during the vent clearing process due to the imbalance of pressure between the drywell and wetwell air space.

The vent header thrust load increase of 1.056 will be used to define the LOCA Jet/ Bubble Drag load increases.

Earthquake

The 3-inch increase in submergence represents an increase in volume or water weight. The Phase 1 Altran Draft Report concluded that the current maximum submergence is 50 inches and will increase to 53 inches [7.3.4, Attachment 1: Pool Swell Shell Pressure Determination for Normal Operating Conditions at 0.0 ∆P]. Based on the Torus Shell Analysis calculations for the current submergence of 50 inches the weight of the water volume for the 1/32nd FEM is 202,640 lbs. [7.4.5, Section III-1, Page 40]. The calculation also provides a water weight of 207,417 lbs. at 53 inches of submergence. The calculation also provides the metal weight for the model of 34,784 lbs. [Section III-1, Page 44]. Reviewing the results:

Table 8 - Consideration of Water Weight Adjustment for +2 Inch Submergence

1/32nd FEM Submergence in.	Water Weight lbs.	Metal Weight lbs.	Total Weight lbs.
50	202,640	34,784	237,424
53	207,417	34,784	242,201

The increase in total weight is 2.0% (242,424/ 237,424-1) which is negligible with respect to the seismic analysis of the structure.

Froth Region I

The Froth Region I load occurs as a result of pool impact on the VH deflector as described in Section 1.4 Table 2 - Terminology of this report. Section 2.10.6 discusses that pool impact load with the bottom of the vent head deflector is related to the square of the velocity of the rising pool at time of first contact. **Based on Table 6 the adjustment factor from 1.7 ∆P to 0.0 ∆P is a 0.84 (256.0/ 306.3) reduction. However, for reporting purposes the factor used will be 1.0 for Froth Region I for 0.0 ∆P Accident and NO cases. A +3" submergence increase will result in additional load reduction based on the test data.**

Froth Region II

Froth Region II loads result from air bubble break through above the pool at maximum height as described in Section 1.4 Table 2 - Terminology. Section 2.10.6 discusses that the load is related to the square of the velocity at maximum pool height. **Based on Table** 7 **the adjustment factor from 1.7 ∆P to 0.0 ∆P is a 0.68 (144/210.3) reduction. However, for reporting purposes the factor used will be 1.0 for Froth Region II for 0.0 ∆P Accident and NO cases. A +3" submergence increase will result in additional load reduction based on the test data.**

Pool Fallback

Pool Fallback load affects the ECCS suction strainers. However, Section 2.10.7 concluded that the load is insensitive to submergence **Therefore the Adjustment Factor is 1.0 for a 3" submergence increase for 0.0 ∆P Accident and NO cases.**

2.10.13 0.0 ∆P PS Dynamic Load Factor

During the Mk I Program to facilitate the FEA PS pressures were in some instances applied statically along with the appropriate DLF to obtain Shell Stress results [Section 1.4 Table 2 - Terminology].

The 1/16th Model FEA from the Altran Draft Technical Report 13-0541-TR-001 was run statically with a DLF of 1.228 applied (See Section 2.6). Combined PS download phase vertical saddle and column load compared favorably (within 1%) between the original program 1/32nd model and the 1/16th model.

Table 9 - Comparison of FEM PS Reaction Loads (Kips)

Model	Inner Column	Outer Column	Saddle	Total	References
1/32nd Results x2	270	300	1,267	1,837	[7.4.3 Page 21 of 175]
1/16th Results	381	480	954	1,816	[7.3.4, Model confirmation check. Detail not addressed in the report text]

Table Notes:

- The difference between the two models in load distribution for the 0.0 ∆P ↓ PS Download phase results from the modeling refinements. These include application of both vent and non-vent bay PS pressure loads versus scaling of non-vent bay results to obtain the total load (See Section 2.5).

  For example, the 1/16th model more accurately reflects the RG and saddle off-set. The column tie plates are also more accurately modelled. Boundary conditions on the 1/16th model allow moment flexibility at the mitre joint so that the structure acts as a multi-span beam versus a cantilever.

- The 0.0 ∆P PS Download Phase DLF is 1.228 as described above.

2.10.14 Earthquake Load

(a) Shell Stress Intensity

The stress intensity results are reported for two bounding ECs 14 & 20. These ECs use the OBE load condition; therefore, the OBE stress intensity will be adjusted to obtain SSE stresses. A static analysis was performed with OBE accelerations of 0.08H and 0.06V ($OBE = \sqrt{4 \times 0.08^2 + 0.06^2} = 0.171$). SSE accelerations are 0.15H and 0.10V (($SSE = \sqrt{4 \times 0.15^2 + 0.10^2} = 0.316$).) [7.4.5, Section III-(7), Page 152]. Factor OBE by 1.85 (0.316/0.171) for SSE. Note the DISTRES Computer Program Check was reviewed to validate that both OBE and SSE cases were analyzed for shell stress intensity [7.4.2, Section IV, Pages 23 & 24].

The Adjustment Factor as described above for the EQ load condition is SSE = 1.85 OBE.

2.11 Bounding Event Combinations

The ECs to be reviewed are those Structural Element and TAP (Cl 2 & Cl 3) ECs associated with the PS load conditions as documented in the PUAAG [Section 5, Component-Load-Service Limit Assignments, Tables 5-1 and 5-2 in 7.2.1].

2.11.1 Structural Elements

The PUAAG lists 27 ECs for evaluation of Structural Elements by the Mk I Program. Of the 27 ECs, Table 10 below lists those which contain PS Load Conditions. Only the PS load conditions will change for Normal Operation from the 1.7 ΔP to 0.0 ΔP. The LDR describes the timing of the events and PS is a short term event lasting approximately 1.5 seconds. The Condensation Oscillation and Chugging events occur later in the event as given on Figures 3.0-1 through -5 [7.2.2] long after the PS event has ended. There are 3 Service Levels involved however Service Level A & B have the same allowable stress intensity value for P_M and/ or $P_L + P_B$. Therefore, EC 18 will have higher stress results than EC 16 because it requires the addition of the OBE Load Condition. Using the same bounding philosophy for Service Level C, ECs 19, 22, 24 and 25; EC 25 will bound the other ECs based on Table 5-1 of the Structural Acceptance Criteria [7.2.1]. EC 25 is the combination with maximum Load Conditions included [Table 10 - PUAAG PS Event Combinations]. Note that the SSE load condition bounds the OBE load condition as the analyses were performed statically and SSE acceleration levels are larger in magnitude [Section 2.10.14].

Table 10 - PUAAG PS Event Combinations

Service Level (Notes 1 & 2)	EC Number	Load Conditions (Note 3)
A	16	PS + N
B	18	PS + N + OBE
C	19	PS + N + SSE
C	22	PS + N + SRV
C	24	PS + N + OBE + SRV
C	25	PS + N + SSE + SRV

Table Notes:

1. Allowable Stress Intensity Values for ASME BVPC Service Levels for A and B are the same:
   a. $P_M < S_{MC}$
   b. $P_L + P_B < 1.5\ S_{MC}$
2. Allowable Stress Intensity Values for ASME BVPC Service Level C:
   a. $P_M < S_Y$
   b. $P_L + P_B < 1.5\ S_Y$
   c. Note: for Ferritic steels the S_Y values control.
3. Allowable Stress Intensity Values for ASME BVPC Service Level D Ferritic Materials:

a. $P_M < 0.7\ S_U$

b. $P_L + P_B < 1.5 \times 0.7\ S_U$

4. SSE > OBE and used for all cases.

2.11.2 TAP (CI-2 &CI-3)

The TAP ECs are identical to those developed for the Structural Elements. However, the corresponding Service Level is B for all of them. Therefore EC 25 is bounding for those ECs with the 0.0 ∆P PS load condition included. Per Table 5-2 and Note 4 the allowable stress value for all Service Level B cases is 2.4 S_H.

2.12 Updated Construction Code

As a part of the JAF project to eliminate the differential pressure (0.0 ∆P) between the drywell and torus during normal operation, Imperia will evaluate/ review all associated structural elements. These Mk I Program MC structural elements were evaluated during the Mk I Program for all Load Conditions (e.g., N, EQ, T_A, R_A, P_A, PS, CO, and CH) using the 27 PUAAG Event Combinations listed on Table 5-1 with a drywell to wetwell differential pressure (1.7 ∆P) for normal plant operation [7.2.1, Section 5 Component-Load-Service Limit Assignments]. The TAP CI 2 & CI 3 piping systems were similarly evaluated using Table 5-2.

2.12.1 Original Construction Codes of Record

The original Construction Codes prior to the JAF Mk I Program for structural elements, associated supports and TAP are as follows:

- Pressure Boundary Structural Elements: ASME BPVC SC III, "Rules for Construction of Nuclear Vessels" – 1965 Edition with 1966 Winter Addenda [7.5.9] based on UFSAR Para. 16.2.3.1 [7.6.3].
- Structural Element Supports: AISC, "Manual of Steel Construction," – The 7th Edition 1970 will be used as it is closest to the Mk I Program date [7.5.10]. UFSAR Para. 16.2.3.1 does not specify an AISC Edition [7.6.3].
- TAP: ASME USAS B31.1.0, Power Piping -1967 Edition [7.5.7]. UFSAR Para. 16.2.3.1 [7.6.3].

2.12.2 Mk I Program Updated Construction Codes of Record

The Mk I Program Structural Acceptance Criteria is documented in the PUAAG [7.2.1]. The criteria are consistent with the NUREG-0661 SER prepared by the NRC to accept the Program results [7.1.1]. The Structural Element and TAP evaluation criteria were developed in accordance with the 1977 Edition of the ASME BPVC Section III, Division 1 for the affected PC Structural Elements and TAP [7.5.1]. Therefore the 1977 Edition of SC III is the "Construction Code" as reconciled by the Mk I Program.

- Pressure Boundary Structural Elements and TAP: ASME BPVC SC III, "Nuclear Power Plant Components" – 1977 Edition [7.5.1]
- Structural Element Supports: AISC, "Manual of Steel Construction," – 7th Edition 1970.

The Structural Elements, Supports and TAP evaluated by TES during the Mk I Program include: MC Torus and Supports, associated components and internal structures (e.g., RG, supports and seismic restraints, and etc.), Internal Vent System and Structures (e.g., VP, VH, DCs, VH deflector, monorail and catwalk) and TAP [7.3.2 & 7.3.3].

2.12.3 Construction Code of Record – Normal Operation at 0.0 ∆P

Imperia will use a later edition of the Construction Code SC III Subsection NE for the Structural Element (i.e., not the TAP) evaluation of the 0.0 ∆P design change for normal plant operation [7.5.2]. However, for the TAP Imperia will use the 2007 Edition of ASME B31.1, "Power Piping," a later Edition of the Original Construction Code for the piping [7.5.8].

2.12.3.1 SC XI Reconciliation Requirements

The proposed use of a later Construction Code Edition is consistent with the requirements of the ASME BPVC SC XI outlined in the JAF ASME Section XI Repair/Replacement Program [7.6.1]. For this project design change, the current NRC approved ASME BPVC SC XI provides the following excerpted requirements [7.5.6]:

IWA-4220 Code Applicability

IWA-4221 Construction Code and Owner's Requirements

An item to be used for repair/ replacement activities shall meet the Owner's Requirements. Owner's Requirements may be revised, provided they are reconciled in accordance with IWA-4222.

IWA-4222 Reconciliation of Code and Owner's Requirements

1. Only technical requirements that could affect materials, design, fabrication or examination and affect the pressure boundary, or core support or component support function, need be reconciled.

IWA-4223 Reconciliation of Components

Reconciliation of later Editions or Addenda of the Construction Code or alternative Codes as permitted by IWA-4221 is not required.

Therefore, use of a later Edition of the Construction Code does not require reconciliation. However, the later Edition for the MC structural elements must be NRC approved by 10CFR50.55a and used in its entirety [7.1.3]. The latest 10CFR50.55a approved ASME BPVC Edition is 2007 with 2008 Addenda for both SC III and SC XI [7.5.2 & 7.5.6]. Imperia will use the latest Edition of SC III for the Mk I Program evaluation/ review. The advantage of the later Code edition is discussed in Sections 2.12.3.2 and 2.13.

The Code Equations for the 0.0 ∆P evaluation using the proposed Code Editions were compared against the Mk I Program evaluation using the 1977 ASME BPVC SCIII and there are no changes. The allowable stress intensity values have changed as described below in Section 2.12.3.2.

The TAP Code will be a later Edition of the original Construction Code B31.1. The 2007 Edition of B31.1, "Power Piping" also adopted the increased allowable stress values for S (See Table 11 below) [7.5.8, Table A-1 Carbon Steel]. The Code piping equations have not changed and are consistent with the 1977 Edition of SC III the previously reconciled Code of Record.

2.12.3.2 Code Case 2290

In 1998 Code Case 2290 was approved for use by the ASME BPVC [7.5.3]. The Code Case effectively reduced the design margin on tensile stress from a factor of 4.0 to 3.5 based on a significant effort by the Code body. After the Code Case approval, the 1999 Addenda of Section II Part D was issued for use with the lowered design margins. Presently the 2007 Edition with 2008 Addenda of SC II Part D which is referenced by SC III contains stress values consistent with the 3.5 factor on S_u. Since this edition of SC III is approved by NRC the increased allowable stress values may be used for the design change to 0.0 ΔP for normal operation. The 2007 Edition with 2008 Addenda of SC III shall be used in its entirety.

2.13 Materials and Allowable Stress Intensity Information

The basic PC materials associated with the Torus evaluation are ferritic carbon steel. A comparison will be performed based on values of S_Y and S_U from 1977 to 2008 Code Editions to assure that the material properties are consistent. In 1977 the ferritic material properties were in the Appendices to SC III for the components; Table I.10.1 for S_{MC} and Table I-1.1 for S_{M1} allowable stress values and Table I.7.1 for Cl 2 and Cl 3 piping allowable stress values [7.5.1]. In 2008 the material properties are in SC II Part D for the components; Table 2A for S_{M1} allowable stress values and Table 1A for S the Cl 2 and Cl 3 piping allowable stress values [7.5.4]. Note, based on NE-3134.6, Allowable Stress Intensity and Stress Values, S_{MC} = 1.1 x S [7.5.2].

B31.1 2007 allowable stress values are also listed for use in evaluation of the TAP [7.5.8, Table A-1 Carbon Steel].

Table 11 - ASME BPVC Material Properties

Structural Element	Mat' l	1977 ASME Code SC III – Appendices ksi					2008 ASME Code SC II – Part D ksi					B31.1 2007
Stress Value		S_U (min)	S_Y (min)	S_{MC}	S_{M1}	S	S_U (min)	S_Y (min)	S_{MC}	S_{M1}	S	S
Torus Shell Ring Girder Vent System	A516 Gr 70	70	38	19.3 650^{0}F	23.3 100^{0}F	17.5 650^{0}F	70	38	22 500^{0}F	23.3 150^{0}F	20 500^{0}F	20 500^{0}F
Torus Supports	A36	58	36	13.9 700^{0}F	Not Listed	12.6 650^{0}F	58	36	18.3 650^{0}F	19.3 500^{0}F	16.6 650^{0}F	16.6 650^{0}F
Torus Attached Piping	A106 Gr B	60	35	16.5 650^{0}F	20.0 400^{0}F	15.0 650^{0}F	60	35	18.8 650^{0}F	20.0 300^{0}F	17.1 650^{0}F	17.1 650^{0}F
Torus Attached Piping	A333 Gr 1	55	30	15.1 650^{0}F	18.3 200^{0}F	13.7 650^{0}F	55	30	17.3 500^{0}F	18.3 200^{0}F	15.7 500^{0}F	15.7 500^{0}F
Tee-Quencher Bifurcated Elbow	SA403 WP316L	70	25	17.2 350^{0}F	16.1 350^{0}F	15.6 350^{0}F	70	25	17.8 350^{0}F	16.3 350^{0}F	16.2 350^{0}F	15.8 350^{0}F
ECCS Suction Strainers	SA240 Tp 304	75	30	20.7 100^{0}F	20 300^{0}F	18.7 100^{0}F	75	30	22 350^{0}F	20 200^{0}F	20 200^{0}F	20 100^{0}F

Based on a review of typical torus ferritic materials there have been no changes in properties (S_U & S_Y) from 1977 to 2008. Therefore, using the allowable stress values consistent with the lowered design margin is acceptable provided that all structural element evaluations conform to the requirements of SC III, 2007 Edition with 2008 Addenda.

Based on the material properties presented the margin gained on allowable stress values for MC Structural Elements and for Cl 2 and Cl 3 piping approximately 14%. Note: that Torus temperature per Section 2.1 is controlled by Technical Specification during normal operation. At the start of an Event the torus will be at local ambient temperature for evaluation purposes.

2.14 Weld Allowable Stress Values

In general, the TES weld evaluation used design by analysis methodology (i.e., subsection NE-3200) and doubled the average primary shear stress to obtain the stress intensity and compared to the P_M allowable stress intensity S_{MC}.

Alternatively, per Para. NE-3227.2, “Pure Shear,” the average primary shear stress in the weld can be compared directly to 0.6 S_{MC} [7.5.2].

The welds; RG, Inner and Outer Column and Saddle to Torus Shell are structural for the Torus support system and not pressure boundary integrity welds. Therefore, Table NF-3324.5(a)-1 can apply as well. The Code required weld material is E70XX electrode which has tensile properties that match with the A516 GR 70 material (i.e., S_U = 70 ksi) [7.5.11, SFA-5.1 “Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding and Table 4 ASME BPVC Materials Properties]. Therefore, S_{MC} which is based on 1.1 x S_U (70 ksi)/3.5 = 22 would be the same value for both materials [2.13]. The S_Y = 58 ksi for the E70 family of electrodes.

Table 12 - Double Sided Weld Example

ASME Code Allowable Stress Limit	Allowable Stress Value ksi	Allowable Fillet Weld Load kips/ in	Allowable Base Metal Load kips/ in	Weld Stress Value	References
Weld Area of ½ in Double Sided Fillet Weld		½ x 2 x .707 = 0.707 in^2	½ x 2 = 1.0 in^2		
S_{MC}	22	22 x 0.707 x ½ = 7.78	22 x 1/2 = 11	Stress Intensity = 2 x Avg. Shear Stress	NE-3221.1 General Primary Membrane Stress Intensity [7.5.2]
0.6 S_{MC}	0.6 x 22 = 13.2	13.2 x 0.707 = 9.33	13.2	Avg. Shear Stress	NE-3227.2, “Pure Shear” [7.5.2]
Weld: 0.3 S_U	0.3 x 70 = 21	21 x .707 = 14.85	N/A	Avg. Shear Stress	NF-3324.5(a)-1 [7.5.2]
Base Metal: 0.4 S_Y	0.4 x 38 = 15.2	N/A	15.2	Avg. Shear Stress	NF-3324.5(a)-1 [7.5.2]

Based on the above table for a fillet weld the bounding stress is the fillet weld and not the base metal stress. Per NF-3324.5, “Design of Welded Joints,” The allowable stress limits for fillet welds shall be as specified in Table NF-3325.5(a)-1 [7.5.2]. Per (c) Service Limits, Level A through D and Test are given in Table NF-3312.1(b)-1. Level D refers to Appendix F and F-1337, “Requirement for Support Fillet Welds,” requires the allowable stress value of 1.7 times the Design Load described in NF-3324.5.

- Level A: 0.3 S_U
- Level B: 1.33 x 0.3 S_U = 0.40 S_U
- Level C 1.5 x 0.3 S_U = not greater than 0.42 S_U
- Level D 1.7 x 0.3 S_U = 0.51 S_u
- Level E 2.0 x 0.3 S_U = 0.60 S_U (per TES Catwalk Calculation [7.4.23])

2.15 Torus Support System

The torus support system is located at the mitre joint with offset RG. The 0.0 ∆P ↓ PS NO Download Phase saddle and column loads are calculated in Attachment B for ECs 16, 18 and 25. It is apparent from the results that the direct SRV and SSE load contribution from the FEA is negligible. Therefore, analysis results for these components and shell welds can be simplified as they need not consider the combined SRV and SSE load.

2.16 Mark I Long-Term Containment Program, Evaluation of the Torus Vent System for Increased Thrust Loads Due to Water in the Vent Pipe Bowl

2.16.1 Discussion

The MK I Program was completed for the PC torus suppression chamber and associated components upon NRC approval via issuance of the SER [7.1.1]. One modification resulting from the program was the cutting and capping of the eight vent pipe bowl drains at PNPS, JAF, and VY. The drain lines were modified at many BWRs because they represented a long run of unsupported piping from the vent pipe low point to a location below the torus suppression pool surface. The Mk I Program determined that during a LOCA the drains would be severely overstressed from the pool swell quasi-static event load which for the vent system and associated components includes; water clearing, gas clearing, bubble formation and breakthrough, and impact and drag load from pool uplift and then fallback [7.4.1, C.1 History].

The eight one-inch diameter vent line drains were cut and capped above the pool at the vent pipe bowl to avoid more costly modification. In fact, the drain lines were often plugged with debris and would not permit flow resulting in the need to manually drain the vent pipe bowls during outage periods. However, substantial accumulation of standing water was not anticipated based on the operational history with plugged drain locations. Therefore, it was agreed that any condensation in the vent system would be minimal based on deadweight considerations and the accumulation of standing water would be manually drained during outage periods, as necessary.

However, GE notified the industry via an Information Notice Communication (IN 2003-07) of two other nuclear power plants with a substantial amount of standing water that had accumulated in the vent pipe bowls. The IN stated that the load definition for the MK I Program did not account for the effects of accumulated water in the bowls. Water is carried to the suppression pool by the gas/ steam mixture during a postulated LOCA. Substantial accumulation can result in increased vent system thrust loads as the additional mass traverses from the vent pipe bowl through the ring header into the downcomers and below the pool surface to be quenched [7.1.2].

2.16.2 Methodology

A working group of the BWROG was formed in 2003 to better define the thrust load increase due to substantial accumulation of water in the vent pipe bowls. The Group determined that the most accurate way to prepare a load definition was to perform scaled testing. Computational methods cannot accurately account for the water carryover transient due to the significant number of variables that must be accurately defined. The problem is too complex for the present level of technology. This conclusion is consistent with the Mark I Program philosophy where much of the load definition had been prepared from empirical data developed by full and partial scale testing [7.3.1, Section 5 Conclusions and Recommendations].

Continuum Dynamics, Inc. (CDI) was subcontracted by the BWR Owner's Group (BWROG) to develop the appropriate scale factors and design/ build a scaled test facility. CDI was involved in the original MKI Program scale testing and it was agreed by the BWROG that their experience and knowledge base was important to program success. Upon the successful completion of the test program CDI provided results of the vent system thrust load to the BWROG. These results were reviewed by Entergy (and the other utilities). The Entergy review was completed at the WPO Corporate Offices and by each of the three plants. The increase in vent system thrust load is defined as less than 10% based on the scaled empirical test results as summarized in the Entergy Nuclear Engineering Report.

It is noted that the study performed by Continuum Dynamics which determined a load increase of less than 10% used 500 gal/ vent pipe bowl or a total of 4000 gal of water. The additional load obtained was 53 kips to be added to the total thrust load of 565 kips. Based on the JAF plant geometry 2611 gal of water can reside in the vent bowls. Taking this information into account the load increase at JAF would be 6.1% as calculated below:

$$\frac{2611\ gal}{4000\ gal} \times \frac{53\ kips}{565\ kip} \times 100 = 6.1\%$$

Entergy prepared an Engineering Report for the three plants (PNPS, VY & JAF): WPO-ME-06-00012 Rev 0, "Effect of the Vent Bowl Water Accumulation on the LOCA Loads" based on the results of the CDI testing, separate GE LAMB analysis and Entergy GOTHIC model thrust load calculations [7.3.1].

The report concluded:

> "Although it was not specifically analyzed as part of the Mark I Containment Program, the conservatisms in the containment analysis methodology bound the effects of the water that may collect in the vent bowls at JAF, PNPS and VY with respect to the containment loads."

2.16.3 Conclusion

Based on the results provided above; Imperia concludes that the additional water in the vent pipe bowls has a negligible effect on the MK I Program Event Load for the Primary Containment. Therefore, the vent system will meet ASME Code Design requirements as outlined by the Structural Acceptance Criteria – Plant Unique Analysis Application Guide (PUAAG) for this condition [7.2.1]. These requirements are consistent with US NRC NUREG-0661 [7.1.1].

The Thrust Load Adjustment Factor for Water in the Vent Pipe Bowls is 1.0 based on the discussion above.

2.17 Torus ECCS and RCIC Suction Strainers

2.17.1 1998 Upgrade

The JAF ECCS and RCIC Suction Strainers were upgraded to handle additional debris loading in 1998 after the end of the Mk I Program in accordance with the requirements of NRC Bulletin 96-03 [7.1.4]. The improved ECCS and RCIC strainer upgrades consist of both Residual Heat Removal (RHR) suction penetrations (X-225 A&B), both Core Spray (CS) suction penetrations (X-227 A&B), the High Pressure Coolant Injection (HPCI) suction penetration (X-226) and the RCIC suction penetration (X-224) [7.4.20, Section 1.0].

The Mk I Program hydrodynamic loads including CO and CH, SRV Jet and Bubble, LOCA Jet and Bubble, and PS Fallback loads were analyzed for the strainers and related penetrations. Strainer FEMs for analysis of the hydrodynamic loads were built for application of the maximum or bounding Load Conditions for each ECCS strainer. Results were evaluated in accordance with the ASME Code [7.5.5, 7.4.67 Para. 4.0 & 7.4.22 Para. 4.0].

2.17.2 2018 Upgrade

The ECCS Suction Strainer modification was completed during JAF Refueling Outage R23. Technical Report 13-0541-TR-002 is revised to incorporate the results from the Engineering Change EC 622608. The following calculations are referenced in support of this modification:

- A384.F02-06 Rev. 2C.1 and 2C.2, “James A. FitzPatrick Nuclear Power Plant: Strainer Performance Analysis,” [7.4.62]. Previous revisions are references: 7.4.10, 7.4.11 & 7.4.12

  This revision and previous revisions to this calculation address the performance of the ECCS RHR and CS Suction Strainers. These revisions include the following information:

  The purpose of the original calculation was to estimate head loss across the ECCS and RCIC Suction Strainers [7.4.62]. Revision 2 was prepared as a comprehensive revision with revised design input and debris load calculations. This revision was prepared. after the installation of the 1998 Upgrades.

  Revision 2A, updated information on strainer debris loading due to Drywell insulation composition [7.4.12].

  Assumptions on suppression pool debris composition and distribution were revised in EC42271 as a markup of Rev 2 [7.4.11].

  Revision 2C.1 and 2C.2 addressed performance degradation due to the installation of the ECCS Suction Strainer Modification which is termed a “Clamshell

  Cover” [7.4.62].

  This family of calculations is not affected by 0.0 ΔP NO. The PS event is relatively short duration and ends before the RHR and/or CS systems are placed into service.

- A384.F02-07 Rev. 2, “Mark I Hydrodynamic Submerged Structure Loads on the Replacement Core Spray, RHR, HPCI and RCIC Suction Strainer Assemblies” [7.4.20]. This calculation contains the following information:

  Mk I Load Conditions were calculated in accordance with the subject calculation.

  Section 9.0 of the document indicates that Jet Discharge Velocity and Acceleration used Figure A-762 of the QSTF Plant Unique Tests [7.2.5]. The referenced Figure A-762 Test 5 corresponds to 0.0 ΔP PS Load Condition. This figure was conservatively used for LOCA Water Jet Load Condition. This Load Condition is conservatively added to the LOCA Bubble Drag Load Condition.

  Section 10.0 also indicates that the LOCA Bubble Drag Loads are conservatively calculated for 0.0 ΔP.

  The 0.0 ΔP NO PS Load Condition Adjustment Factor for the two LOCA load conditions discussed above is 1.0 [Section 5.1, Table 13].

  Section 11.0 indicates that the PS Fall Back loads were calculated for the peak pool height. This is bounding for the all PS submerged structure load conditions. The 0.0 ΔP NO PS Load Condition Adjustment Factor for PS Fallback is 1.0 [Section 5.1, Table 13].

  Therefore, the PS load conditions considered for the ECCS Suction Strainers are all calculated for the 0.0 ΔP case. Based on the Section 5.1, Table 13 - Load Condition Adjustment Factors for Structural Element Evaluation of this TR all Submerged Load adjustment factors for the Strainer PS Hydrodynamic Loading are 1.0 for 0.0 ΔP NO.

- A384.F02-10 Rev. 4, “Core Spray Penetration X-227A TAP Piping Reanalysis for the Replacement Suction Strainer Assemblies,” [7.4.45].

  This calculation supersedes the original TES X-227A analysis. Section 3.0 discusses the methodology for the preparation of the calculation. The methodology as discussed in both Sections 3 and 10 for PS shell motion used both the 0.0 ΔP Accident and 1.7 ΔP PS NO Load Conditions for torus external loads on the Piping, Pipe Supports, Torus Penetration and Branch Piping.

  The results from the calculation will require adjustment for 0.0 ΔP NO. For the PS Shell Motion, the maximum Load Condition Adjustment Factor from Table 13 of 1.11 will be used.

  The internal Submerged Structure Loads are discussed in Section 11. The load conditions associated with PS are LOCA Bubble Drag and Water Jet and PS Fallback. These load conditions were calculated in accordance with A384.F02-07.

  As discussed in A384.F02-07 above, the submerged structure loads all have a Load Condition Adjustment Factor of 1.0.

- A384.F02-11 Rev. 4, “Core Spray Penetration X-227B TAP Piping Reanalysis for the Replacement Suction Strainer Assemblies,” [7.4.46]

This calculation supersedes the original TES X-227B analysis. Section 3.0 discusses the methodology for the preparation of the calculation. The methodology as discussed in both Sections 3 and 10 for PS shell motion used both the 0.0 ΔP Accident and 1.7 ΔP PS NO Load Conditions for torus external loads on Piping, Pipe Supports, Torus Penetration and Branch Piping.

The results from the calculation will require adjustment for 0.0 ΔP NO. For the PS Shell Motion the maximum Load Condition Adjustment Factor from Table 13 of 1.11 will be used.

The torus internal Submerged Structure Loads are discussed in Section 11. The load conditions associated with PS are LOCA Bubble Drag and Water Jet and PS Fallback. These load conditions were calculated in accordance with A384.F02-07.

As discussed in A384.F02-07 above, the submerged structure loads all have a Load Condition Adjustment Factor of 1.0.

- A384.F02-12 Rev. 4, "RHR Penetration X-225A & B Suction Strainer Assembly and Torus Penetration Analysis," [7.4.63].

  PS Hydrodynamic Loads

  The PS Load Conditions considered applicable in this calculation for the RHR Suction Strainers were listed as PS Motion and LOCA Bubble Drag and Water Jet Loads and Pool Fallback.

  The two ECs to be reviewed for Pipe Stress are numbers 2 and 4 listed in Table 3-3 of the report.

  For the convenience of the reader the following Kinectrics designations are provided:

  - PS Pool swell internal structure loads at 1.7 ΔP. Note these loads were not evaluated for the strainer and PS0 loads were used conservatively.
  - PS0 Pool Swell internal structure loads at 0.0 ΔP
  - PSI Pool Swell inertial loads at 1.7 ΔP
  - PS0I Pool Swell inertial loads at 0.0 ΔP. Note: It has been determined and Kinectrics concurs that these loads were not evaluated for the strainer. Attachment C only provides one PS time history for the 1.7 ΔP Load Condition.

  Per Section 2.11.2 EC 2 shall be evaluated to Service Level B as given in Table 5-2 of the Mk I Program Structural Acceptance Criteria [7.2.1]. Note 4 provides an alternative limit on the Equation 9 Pipe Stress of 2.4 S_H. However, the PS0I inertia loads were not evaluated.

  EC 4 uses the 1.7 ΔP PSI inertia load condition along with the conservative PS0 internal structure loads.

  The PSI load condition used to determine pipe stresses and loads for the Penetration and Internal Support shall be increased by the 0.0 ΔP NO PS

Load Condition Adjustment Factor of 2.56 [Section 5.1. Table 13] to account for the unanalyzed PS0I load condition.

The LOCA Bubble Drag and Water Jet Loads per A384.F02-07 were also calculated for the submerged structures using the bounding case of 0.0 ∆P NO [7.4.20]. Per the previously referenced table they shall be used with a Load Condition Adjustment Factor of 1.0.

As stated in the A384.F02-07 calculation the submerged structures are bounded by PS Fallback and the load condition adjustment factor is 1.0 [7.4.20].

- A384.F02-15 Rev 3, "Torus Ring Girder and Shell Local Evaluation for Reaction Loads from the Core Spray and RHR Suction Strainer Assembly Supports," [7.4.64]

  This calculation addresses the local loads on the Ring Girder and Torus Shell as a result of the addition of ECCS Suction Strainers (RHR & CS) support types S1, S2 and S3.

  The report also limited the corrosion allowance for the lower half of the Torus Shell to 0.100 inches as annotated in the Table 4.4.1. Note that this limit is a result of conservatively using the maximum reported stresses developed by TES and are listed in Table 17. This limit was later increased to 0.143 as discussed in Section 2.8.

  The RHR (X-225 A&B) and CS (X-227 A&B) Torus Internal Supports are evaluated with their respective TAP evaluation in Attachment I.

- A384.F02-16 Rev 4, "RHR Suction Strainer Support Qualification for Support Mark Number X-225A-S2 and X-225B-S2," [7.4.65]

  Revision 3 to this calculation qualified the RHR Suction Strainer submerged supports at the ring girder location S2. Revision 4 of the calculation adjusted the results by a factor of 1.09 to account for the Clamshell Modification and the RHR discharge loading.

  The RHR (X-225 A&B) and CS (X-227 A&B) Torus Internal Supports are evaluated with their respective TAP evaluation in Attachment I.

- A384.F02-17 Rev 6, "Core Spray and RHR Suction Strainer Support Qualification for Support Mark Numbers X-225A-S1, X-225B-S1, X-225A-S3, X-225B-S3, X-227A-S1 and X-227B-S1." [7.4.66]

  Earlier revisions to this calculation qualified the CS and RHR Suction Strainer submerged supports at the ring girder locations. Revision 6 of the calculation adjusted the results by a factor of 1.046 to account for the Clamshell Modification and the RHR discharge loading.

  The RHR (X-225 A&B) and CS (X-227 A&B) Torus Internal Supports are evaluated with their respective TAP evaluation in Attachment I.

- A384.F02-19 Rev.4, Structural Qualification of the Replacement Core Spray and RHR PCI Suction Strainer Modules," [7.4.67]

  This calculation provides qualification of the CS and RHR ECCS Suction Strainers with added clamshell repair modules and it also addresses the strainer disks affected by RHR discharge jet load.

Section 9.4.1 discusses hydrodynamic load conditions applied to the strainer components and references A384.F02-07 for Hydrodynamic Load Calculations. Applied load conditions listed that are affected by 0.0 ΔP NO are PS Fallback, LOCA Bubble Drag and Water Jet. As discussed above for A384.F02-07 the affected load conditions were conservatively calculated using the 0.0 ΔP PS Accident Condition and the Load Condition factor is 1.0.

It is concluded that no additional changes to this calculation A384.F02-19 are required. The modification to add the clamshell covers over critical strainer disks is structurally acceptable for 0.0 ΔP NO.

- A384.F02-53 Markup Rev. 1, "Evaluation of the Effect of the Abandoned SRV Ramshead Support Ring Girder Stiffeners on the RHR Suction Strainer Assembly Analysis," [7.4.68]

  Final support load combinations for the ECCS Suction Strainer Clamshell Permanent Modification for the following CS and RHR Strainer Supports are provided in A384.F02-12:

  1. CS X-227B-S1
  2. RHR X-225A-S1 &S3 and X-225B-S2 &S3

  It is concluded that no additional changes to this calculation A384.F02-53 are required. The supports listed have load changes as a result of the modification to add the clamshell covers over critical strainer disks. They will be addressed with calculation A384.F02-12 for 0.0 ΔP NO.

This long-term modification was installed due to a perforated strainer plate concern affects Local Loads on the Torus Shell and Ring Girder, Torus Strainer and Supports, Torus Attached Piping Penetration and the External Pipe stress results as discussed in the calculation summary provided above.

2.17.3 Mark I Program Hydrodynamic Load Conditions for 0.0 ΔP NO - Summary

2.17.3.1 **Timing Consideration of Pool Swell Inertia and Fallback Load**

The Structural Acceptance Criteria [7.2.1, Section 6.3] discusses alternative methods of Event Combination for peak loads that do not occur simultaneously due to time phasing. Therefore, for the CS and RHR ECCS Submerged Suction Strainers 0.0 ΔP NO, the time phasing of the PS Inertia Load applied to the piping system as a forcing function at the Torus Penetration (i.e., a Torus External Load) and the PS Fallback Load which is applied as an impact load to the Torus internal piping will be considered.

INPUT

Applied Loading

A384.F02-07 [7.4.20], "Mark I Hydrodynamic Submerged Structure Loads on the Replacement Core Spray, RHR, HPCI and RCIC Suction Strainer Assemblies,":

The Pool Swell loads include both Torus internal and external loading:

External – Inertia (Time history forcing function at penetration applied to piping)

Internal – Vent Clearing, Fallback

It will be demonstrated that these two PS loads occur at different times and are not additive.

Peak Pool Swell Peak Load

Plant Unique Load Definition [7.2.4, Figure F4.3.1-2], "Net Torus Vertical Load (Zero ΔP)":

The peak downward load occurs at 0.300 seconds from the start of the DBA-LOCA event.

The peak upward load occurs at 0.620 seconds. Therefore, ECCS Suction Strainer Impact due to Pool Swell Fallback does not begin until > 0.620 seconds from the start of the DBA-LOCA event.

Total Water Fallback Height for Strainer Impact

A384.F02-07 [7.4.20], "Mark I Hydrodynamic Submerged Structure Loads on the Replacement Core Spray, RHR, HPCI and RCIC Suction Strainer Assemblies,":

Tables in Section 11 provide the following range of maximum fallback segment height (Hmax):

RHR 11.16 – 14.49 Ft

CS 12.28 – 14.51 Ft

Average Hmax = 13.01 Ft Tables 11-1A & 2A

Duration Pool Swell Penetration Time History Applied Forcing Function

A384.F02-12 [7.4.63], "RHR Penetration X-225A&B Suction Strainer Assembly and Torus Penetration Analysis," Attachment C:

Pool swell inertia time-history forcing function input to the strainer is complete at approximately 0.73 seconds after the start of the DBA-LOCA event. The peak time history upward applied loading occurs at 0.514 seconds based on the forcing function plots.

Pool Swell Penetration Time-History Load Frequency

A384.F02-12 [7.4.63], "RHR Penetration X-225A&B Suction Strainer Assembly and Torus Penetration Analysis," Attachment C:

The time-history applied load frequency is approximately 10 Hz with a corresponding period of 0.10 seconds.

RHR Suction Strainer Modal Frequencies

The analyzed frequencies below 33 Hz per A384.F02-12 [7.4.63], "RHR Penetration X-225A&B Suction Strainer Assembly and Torus Penetration Analysis," Attachment G are given as:

7.87 Hz

10.52 Hz

10.70 Hz

14.82 Hz

15.49 Hz

It has been established that the approximate frequency of the forcing function is 10 Hz and the RHR Suction Strainer model also contains two frequencies in the range of 10 Hz. Therefore, structural response of the ECCS Suction Strainer will correspond to the loading frequency at approximately 10 Hz.

Torus Structural Damping for the Pool Swell Event

NRC Regulatory Guide 1.61 [7.1.5 Section 1.1.1], "Damping Values for Seismic Design of Nuclear Power Plants,": provides Regulatory guidance for containment structures in accordance with the requirements of The Structural Acceptance Criteria [7.2.1 Section 6.2].

Pool Swell is quasi-static therefore use of seismic damping values are conservative. The torus is supported by welded columns and saddle which are anchored to the concrete floor. For the download portion of the event, the saddle and columns bear directly on the reinforced concrete surface. The upload portion of the event is characterized by the use of column and saddle anchorage. Saddle anchors are 2 ft long rock bolts.

Reinforced Concrete is 7% of critical damping and welded structures are 4% of critical damping based on an SSE (i.e., Service Level D Event). The average damping value of 5.5% will be used.

METHODOLOGY

Time of Impact on the ECCS Suction Strainer - Pool Swell Fallback Loading

Impact Time for the Pool Swell Fallback loading using an average Hmax= 13.01 Ft:

$H_{max} = \frac{1}{2} gt^2$ Solving for the time for the pool to fall and impact the strainer is 0.899 seconds.

Where:

Hmax = 13.01 Ft

g = Acceleration of Gravity 32.17 Ft/Sec^2

t = Time Sec

Therefore, impact will occur greater than 0.620 + 0.899 = 1.52 seconds. This is well after the peak downward inertia loading for the torus structure and therefore the loads are not additive.

Pool Swell Inertial Magnitude at Time of Fallback Impact

Logarithmic Decrement from Harris, “Shock and Vibration Handbook,” Chapter 2, McGraw-Hill 2002.

$$\frac{X_n}{X_0} = e^{\frac{-2\pi n\zeta}{\sqrt{1-\zeta^2}}} = 3.1\% \text{ for n= 10}$$

Where:

ζ= 5.5 % Critical Damping

n= number of cycles

The loading frequency is approximately 10 Hz based on the time history plots and there are corresponding ECCS suction strainer structural frequencies in the range. Therefore, the structural response will be at approximately 10 Hz as well.

The peak upward inertia force applied on the strainer has occurred at approximately 0.514 seconds based on the forcing function plots. The forcing function is complete at 0.73 seconds. Loading frequency is 10 Hz or a period of 0.10 second. The time of impact for the Pool Swell Fallback on the ECCS Suction Strainer is 1.52 seconds. The inertia loading will decay over a minimum of 10 cycles (1.52 - 0.514 seconds x 1/0.10 seconds). The pool swell inertia load will therefore be less than 3.1% of the peak upward magnitude. The fallback and inertia loading are not additive.

CONCLUSION

Based on a review of the summarized internal and external pool swell loading at the X-225A and the X-227A Torus Penetrations using 3.1% of the external pool swell load (inertia) SRSS’d with the internal pool swell load (fallback) the penetration load for Event Combination 25 increases results on average less than 1%. This increase is negligible. The pool swell external inertial loads will therefore not be added to the internal fallback loads.

The full Pool Swell inertia load still requires combination with the internal submerged structure Vent Clearing Load. The larger of the PS inertia (PS0I) + Vent Clearing or the Fallback load shall be used for Event Combination 25.

2.17.3.2 Torus Internal Strainers

The Load Condition Adjustment Factors for the long-term modification evaluation are as follows:

- The PS Fallback load was calculated for the 1.7 ΔP NO condition [7.4.20 Para. 11.0]. Based on Section 2.10.7 the Load Condition

Adjustment Factor applied to the original 1.7 ΔP PS Fallback Load Condition to obtain the 0.0 ΔP NO is 1.0. No changes are required.

- The LOCA Jet and Bubble loads used to evaluate the components were conservatively taken at the 0.0 ΔP Accident Condition [7.4.20 Para. 10.0]. Based on Section 2.10.4, the Load Condition Adjustment Factor applied to the original 0.0 ΔP LOCA Jet and/or Bubble Load to obtain 0.0 ΔP NO is 1.0. No changes are required.
- SRV Bubble and Jet loads will not change at 0.0 ΔP NO per Section 2.2.
- CO and CH loads will not change at 0.0 ΔP NO per Section 5.1.

2.17.3.3 **Torus Penetrations**

The Load Condition Adjustment Factors for the long-term modification evaluation are as follows:

- PS free shell stresses at 0.0 ΔP NO are calculated from the 0.0 ΔP PS Accident Condition using the Section 2.10.2 Load Condition Adjustment Factor of 1.11 in EC 25.
- The DW, Hydrostatic, SSE and SRV free shell stresses will not change for 0.0 ΔP NO per Section 5.1.
- Internal loads as determined by the long-term strainer modification are used. This included strainer support loads.
- External Attached Piping loads as determined by the long-term strainer modification are adjusted as described below are used.

2.17.3.4 **Torus External Attached Piping**

The Load Condition Adjustment Factors for the long-term modification evaluation are as follows:

- Core Spray

  The 0.0 ΔP PS NO pipe stress is calculated from the 0.0 ΔP PS Accident Condition pipe stress using the Section 2.10.2 Load Condition Adjustment Factor of 1.11 in EC 25.
- RHR

  The 0.0 ΔP PS NO pipe stress is calculated from the 1.7 ΔP PS NO pipe stress using the Section 2.10.2 Load Condition Adjustment Factor of 2.56 in EC 25.
- The DW, Hydrostatic, SSE and SRV loads will not change for 0.0 ΔP NO per Section 5.1.
- Incorporation of the Internal Strainer loads resulting from the long-term modification.
- Kinectrics ECs S10, S11 and S25 are reevaluated combining 0.0 ΔP PS NO pipe stress for the long-term modification.

- Incorporation of affected piping support loads from the long-term modification.

3.0 DISCUSSION

The TES PUARs were developed to be generic to the five (5) plant consortium. Results were inserted into each plant report later in the process. Based on Imperia's experience it is possible that some of the results were not properly transcribed from the individual calculation packages. Therefore, we have reviewed the as-built calculation packages of record and validated/ corrected the PUAR results, as necessary.

Design inputs and assumptions were developed and provided in Section 2.0. Inputs with respect to initial conditions and known bounding evaluations are provided in Sections 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6. Design input with respect to Torus shell stress analysis is provided in Sections 2.7, 2.8 & 2.9.

3.1 Structural Element Evaluation

The Structural Elements consist of the Torus and Support Structures and Attachment Welds, Internal RG, Vent System, T-Quencher and Miscellaneous Internal Structures (i.e., spray header, catwalk, etc.).

The attachments to this report contain results of the original Structural Element evaluation for NO at 1.7 ΔP which were then adjusted in part based on the Load Condition Adjustment Factors summarized in Table 13 for NO at 0.0 ΔP based on the information provided in Section 2.10. Bounding ECs were developed and compared to the appropriate reconciled Code allowable stress values as discussed in Sections 2.11, 2.12, 2.13, 2.14 and 2.15.

Section 2.16 reflects the result of a post Mk I Program concern for water collecting at the bottom of the VP during an operating cycle due to the cutting and capping of the low point drains during the Mk I Program to eliminate an overstress condition. The result for consideration in the 0.0 ΔP NO evaluation is a negligible Vent System load increase.

Section 2.17 provides information on a JAF modification that was completed in R23 to address plant issues with the ECCS and RCIC suction strainers.

3.2 SRV Discharge Lines

Section 2.2 discusses the bounding SRV DL evaluation using an A1.2 SBA/IBA case for the blowdown in combination with a C3.3 SBA/IBA maximum reflood case. The reflood height is significantly greater than the 0.0 ΔP NO water level. It is the result of steam in the drywell entering the SRV DL via a vacuum breaker valve and condensing in the line. Therefore, the TES bounding case remains bounding for 0.0 ΔP NO.

Section 2.10.11 discusses the SRV DLs acceptability for continued service with new 3-Stage SRV's at JAF.

3.3 TAP Evaluation

The TAP represents the pipe and supports internal to the torus, the torus penetration, and the pipe and supports external to the torus and branch lines. In addition, the evaluation considers stress levels on tight tolerance pipe components such as pumps and valves. The original TAP was segregated into two categories; Large Bore and Small Bore Pipe systems.

ECs evaluated for the original evaluation include:

EC 16 P+N+0.0 ΔP PS

EC 21 P+N+EQ+DBA CO

EC 25 P+N+EQ+SRV+1.7 ΔP PS

EC 27 P+N+EQ+SRV+CH

Therefore EC 25 with 0.0 ΔP PS is evaluated in the TAP Attachment I. In general, during the Mk I Program EC 21 was the bounding case for the pipe system and associated penetration. The goal of the evaluation is to demonstrate that EC 25 for 0.0 ΔP NO will continue to be bounded by EC 21.

Torus attached piping supports are discussed in the TES 5321-2 report as being evaluated in accordance with ASME SC III [7.3.3], However the UFSAR Section 12.5.1.3 Suppression Chamber clarifies that the supports were evaluated in accordance with the AISC Code requirement instead of ASME BPVC Section III. This makes little overall difference as the evaluation methodology and the normal, Service Level A evaluation criteria and allowable stress values are generally the same for both Codes.

It is noted that the TES calculations were performed using Service Level A Allowable Stress Values and that during this effort several JAF supports were reviewed as discussed in Attachment I which validated the conclusion. However, a few AMEC support calculations reviewed in support of Attachment I were found to use the Service Level B Allowable Stress Value increase of 1.33 consistent with both AISC and Section III.

Per Table 5-2 of the PUAAG all Mk I TAP ECs are listed as Service Level B [7.2.1]. However, the PS ECs at 0.0 ΔP NO all contain a footnote allowing use of Service Level D allowable stress values for the Piping. While the PUAAG is silent on evaluation of the pipe supports, standard industry practice is to evaluate pipe supports consistent with the piping.

Therefore, a commensurate increase in support allowable stress values is:

Service Level A: 1.0 (AISC or SC III, NF)

Service Level B: 1.33 (AISC or SC III, NF)

Service Level C: 1.50 (SC III, NF)

Service Level D: Guidance from (SC III, Appendix F).

4.0 METHODOLOGY

The methodology for this evaluation follows closely to the original feasibility evaluation presented in Attachment J developed for JAF by Mr. Nicholas Celia, P.E. and Mk I Program SME. Mr. Celia was Vice President of TES and the Project Manager for the Mk I Program. The Attachment J feasibility study developed individual load condition increases based on 0.0 ΔP NO using Mk I Program criteria in compliance with all Program documents including the NUREG-0661 NRC Safety Evaluation [7.1.1]. The SME for the document herein is Mr. Raymond Pace, P.E. Mr. Pace reported directly to Mr. Celia at TES during the Mk I Program as a Manager, Engineering and worked on a variety of Mk I Program issues associated with the evaluation. In addition, Mr. Pace was designated by TES as the primary expert to present the results of the 5 plant evaluations to the NRC and its Franklin Institute and Brookhaven National Laboratory consultants.

Mr. Celia and Mr. Pace have been in contact with respect to the Attachment J document and both agree that it is a valid methodology to demonstrate Code compliance of the Mk I Program Torus Structural Elements, SRV DLs and the TAP for 0.0 ΔP NO. In general, Mr. Pace has implemented the methodology from the document as it was developed circa 1998.

5.0 SUMMARY OF RESULTS

5.1 Load Condition Adjustment Factors

The Load Condition Factors discussed in Section 2.10 are tabulated in Table 13 below: The table is read as follows:

The X denotes the starting load. The up or down arrow denotes the upward or downward PS phase load condition under consideration.

Example:

The 1.7 ΔP NO Vent System Upward Phase Thrust on the Vent System can be factored by 1.05 to achieve the 0.0 ΔP Accident Condition or factored by 1.17 to achieve the 0.0 ΔP PS NO condition.

Likewise, the 0.0 ΔP accident condition Vent System Upward Phase Thrust on the Vent System can be factored by 1.11 to achieve the 0.0 ΔP PS NO condition

Table 13 - Load Condition Adjustment Factors for Structural Element Evaluation

Load Condition	Structural Element	1.7 ΔP (Normal)	0.0 ΔP (Accident)	0.0 ΔP (Normal)	Unaffected Loads
1.7 ΔP Vent System Thrust (P_{PS}) (Normal)	VH	X ↑	1.05 ↑	1.05 x 1.11 = 1.17 ↑↔	
0.0 ΔP Vent System Thrust (P_{PS}) (Accident) ↑↔	VH		X ↑	1.11 ↑↔	
1.7 ΔP P_{PS} (Normal) ↓	Torus Shell, Column and Saddle Supports	X ↓	2.31 ↓	2.31 x 1.11= 2.56 ↓	
0.0 ΔP P_{PS} (Accident) ↓	Torus Shell, Column and Saddle Supports		X ↓	1.11 ↓	

Load Condition	Structural Element	1.7 ΔP (Normal)	0.0 ΔP (Accident)	0.0 ΔP (Normal)	Unaffected Loads
1.7 ΔP P_{PS} (Normal) ↑	Torus Shell, Column and Saddle Supports	X ↑	1.58 ↑	1.58 x 1.05 = 1.66 ↑	
0.0 ΔP P_{PS} (Accident) ↑	Torus Shell, Column and Saddle Supports		X	1.05 ↑	
1.7 ΔP Impact & Drag (Normal)	Vent System and Structures	X ↑	1.23 ↑	1.05 x 1.23 = 1.29 ↑	
0.0 ΔP Impact & Drag (Accident)	Vent System and Structures		X ↑	1.05 ↑	
1.7 ΔP LOCA JET OR BUBBLE (Normal)	Submerged Structures	X	2.10	2.10 x 1.00 = 2.10	
0.0 ΔP LOCA JET OR BUBBLE (Accident)	Submerged Structures		X	1.00	
1.7 ΔP P_{PS} Froth Impingement Region I (Normal)	Structural Elements in the defined Region I	X		0.83 Use 1.0	

Load Condition	Structural Element	1.7 ΔP (Normal)	0.0 ΔP (Accident)	0.0 ΔP (Normal)	Unaffected Loads
1.7 ΔP P_{PS} Froth Impingement Region II (Normal)	Structural Elements in the defined Region II	X		0.68 Use 1.0	
P_{PS} Pool Fallback	ECCS Suction Strainers			1.0	
SRV Bubble Drag	Submerged Structures				X
SRV Jet Load	Submerged Structures				X
P_{CO}					X
P_{CH}					X
N, R_A & T_A					X

5.2 Post MKI Program Modifications

5.2.1 Water–in-Vent Pipe Bowl

As discussed in Section 2.16.3 Imperia concludes that the additional water in the vent pipe bowls has a negligible effect on the MK I Program EC Results for the Primary Containment.

5.2.2 Torus Water Level – Increased Submergence

As discussed in Section 2.10.12 the following Table 14 contains the adjustment factors to be applied to the Mk I Program Load Conditions to evaluate the acceptability of a +3” increased submergence level to provide additional operations flexibility.

Table 14 - Load Condition Adjustment Factors for +3" Increased Submergence

Load Condition	Adjustment Factor
Downcomer Thrust	1.056
PS ↓ Download Phase	1.039
PS ↑ Upload Phase	0.968
VH and Structures Impact and Drag	1.039
LOCA Jet and Bubble	1.056
Froth Region I	1.0
Froth Region II	1.0
Pool Fallback	1.0
SRV DL Submerged Structure Jet & Drag	1.0
EQ	1.0
Maximum Adjustment Factor	1.056

5.2.3 Power Uprate

As discussed in Section 2.10.9 Imperia concluded that the effect of power uprates on the PS and SRV discharge load is within the accuracy of the original calculations.

5.2.4 GEH Mark I Program Containment Analysis 2019 Update

GEH recently prepared a Short Term Containment Analysis for Zero Drywell-to-Wetwell Pressure Differential [7.2.9]. The purpose of this evaluation was to validate the changes to Mk I Load Conditions for the current plant operational configuration for 0.0 ΔP NO. It also incorporated a proposed increase in initial suppression pool level of +3 inches (i.e., to 14.25 ft). The evaluation used the latest NRC approved analysis methodology. The results confirmed the following load conditions are still valid:

- PS
- CO
- CH

The GEH developed VH Thrust load condition is compared in Table 15 below to the TES 1.7 ΔP NO VH Thrust Loads (i.e., the Licensing Basis Loads) as provided in NEDO 24578 [7.2.4]. Note, these loads were read from time history graphs and as a result there are small differences between the TES and GEH reported licensing basis loads. The differences are negligible with respect to the analytical results.

Imperia developed Load Condition Adjustment Factors to scale VH Thrust and PS from 1.7 ΔP NO to 0.0 ΔP NO. These are summarized in Section 5.1 along with a statistical factor used to account for a single 0.0 ΔP QSTF test versus the four QSTF tests performed at 1.7 ΔP. The adjustment factors were applied as applicable in all cases including the RHR and CS ECCS Suction Strainer results also added during the current revision.

Further, there is an Adjustment Factor on VH Thrust loads developed for the +3" downcomer submergence in Section 2.10.12 and summarized by Table 14 in Section 5.2.2. The factor is 1.056.

The GEH Report was completed after this TR was issued as R0. It is clear from the results given in Table 15 that use of the adjustment factors discussed above is overly conservative.

It is concluded that there is adequate margin to accommodate the 3" submergence increase based on the difference between the current GEH 0.0 ΔP PS NO loads which are lower than the original TES analyzed loads and the NEDO 0.0 ΔP PS Accident Loads.

Table 15 – Vent Header Thrust Load Comparison

Load Direction (Kips)	0.0 ΔP Accident Condition NEDO-[7.2.4]	1.7 ΔP TES 2386-8 TES-[7.4.9]	0.0 ΔP GEH Envelop GEH-[7.2.9]	Ratio GEH/ TES
F1V1	-50	-50	-43.3	0.87
F1H1	-140	-134	-116.7	0.87
F2V	55	50	42.5	0.85
F2H	20.5	20.5	17.7	0.86
F3V	1	1	1.00	1.00
F3H	-3.9	-4.1	-3.73	0.91
FNETV	525	493	469.4	N/A

Table Note:

1. GEH was contacted about application of the Load Condition Factor for a single test. They did not apply one.
2. The Vent System evaluation performed by TES applied individual loads to each Downcomer pair in the model. Total loads were used as a model check (i.e., FNETV, F1V1T, F2VT and F3VT) to assure that the individual applied loads sum to the total load.
3. The GEH evaluation demonstrates that the original 1.7 ΔP PS NO Vent System loading developed through quarter scale testing was conservative compared to their 0.0 ΔP NO evaluation which included the +3" submergence.

5.2.5 3 Stage SRV Installation

As discussed in Section 2.10.11 it was concluded in EC 14122 that the modification to add 3-Stage SRVs at three locations was acceptable with respect to Mk I Program load. Therefore, Imperia concludes that the same SRVs can be added at the other 8 locations.

5.2.6 Torus Corrosion Allowance

As discussed in Section 2.8 a new corrosion allowance was qualified post-MK I Program. A nominal shell thickness of 0.489 inch with a corrosion allowance of 0.143 inch for a full shell thickness of 0.632 inch was evaluated successfully for 1.7 ΔP NO. These results were later modified for the incorporation of the ECCS Suction Strainers as discussed in Section 2.8.

The Shell Stress results with corrosion allowance included were calculated in Table 17 - Torus Shell Controlling Event Combinations and found to be acceptable for 0.0 ΔP NO.

5.2.7 ECCS and RCIC Suction Strainers

Post-MK I Program additional work was completed with respect to reduction of the potential ECCS and RCIC suction strainer debris blockage [Section 2.17]. The design was modified to increase margin. The profile of the strainers was increased to improve capability, the strainer supports were improved and the system was evaluated for acceptability with the Hydrodynamic loading at 1.7 ΔP NO [7.4.20, 7.4.21 & 7.4.22]. The goal of the evaluation with 0.0 ΔP NO is to qualify the sparger with the increased loading for continued service.

In addition, a permanent “Clamshell” design change was developed in parallel with the Imperia effort to qualify the degraded RHR Strainer Disks by modification.

The ECCS Suction Strainer clamshell modification was installed in R23 to protect strainer disks from the RHR discharge thrust load [7.4.62, 7.4.63, 7.4.64, 7.4.65, 7.4.66, 7.4.67, 7.4.68].

Revision 1 to the Imperia TR has been updated to incorporate the installation of the long-term modification. The goal of the evaluation was qualification of the ECCS Suction Strainers for the increased .0 ΔP NO load for continued service.

5.2.8 Penetration X-214 HPCI Steam Discharge Sparger Modification

The original Steam Discharge Penetration was not designed as a sparger. Therefore, the full steam discharge from the HPCI pump impinged upon the torus shell resulting in thermal fatigue and associated cracking. The repair included an improved HPCI sparger design to quench the steam eliminating torus shell thermal fatigue.

The improved HPCI sparger design internal to the Torus with External and Internal Pipe, Penetration and associated Pipe Supports was qualified for continued service for 1.7 ΔP NO [7.4.25].

The goal of the evaluation was qualification of the sparger with the increased 0.0 ΔP NO load for continued service.

5.3 Torus Shell Stress Evaluation

The Torus Shell Stress Evaluation was performed in Attachment A. The results of the evaluation are summarized below.

As discussed in Section 2.3 only the P_M and P_L+P_B Torus Shell stress intensity results are affected by PS loading and as discussed in Section 2.11 the two bounding cases are EC 18 and EC 25.

Torus shell stress results adjusted for 0.0 ΔP NO are provided in Table 16. When compared to the previous shell stress results it was determined that there are no changes as the original controlling ECs remain bounding. Controlling EC results are provided in Table 17.

However, a corrosion allowance was provided as discussed in Section 5.2.6 and the original TES Stress Intensity results were recalculated with the results from the corrosion allowance included [7.4.19].

Table 16 - Comparison of Normal Operation P_M and P_L+P_B Stress Intensity Results

Element	EC 18 P_M		EC 18 P_L+P_B		EC 25 P_M		EC 25 P_L+P_B	
NO	1.7 ΔP	0.0 ΔP	1.7 ΔP	0.0 ΔP	1.7 ΔP	0.0 ΔP	1.7 ΔP	0.0 ΔP
17	4502	9331	4692	9410	5927	10756	6098	10853
19	4493	9565	4970	9650	5934	11006	6342	11022

Table 17 - Torus Shell Controlling Event Combinations

Stress Intensity psi	Location	Event Combination	TES Stress Intensity psi	0.143 in Corrosion Allowance Included psi	2007 Code Allowable psi	Allowable/ Actual
P_m	Free Shell Element 17	EC 20 (DBACO)	13,776	19,251	S_{MC} = 22,000	1.14
P_L	Local Shell Element 160	EC 14 (IBACO)	8,807	17,470	1.5 S_{MC} = 33,000	1.89
P_L + P_B	Free Shell Element 19	EC 20 (DBACO)	14,146	18,843	1.5 S_{MC} = 33,000	1.75
P_L + P_B + Q Alternating Stress	Local Shell Element 148	EC 14 (IBACO)	27,895	53,988	3.0 S_{M1} = 69,900	1.30

Torus shell stress results from Table 17 demonstrate a minimum margin of 1.14 on the Code allowable stress value. The Torus Shell is acceptable for continued service at 0.0 ΔP NO. In addition, it is noted that since the EC with bounding torus shell stress remains unchanged for the free shell P_M, P_L, & P_L+P_B the free shell stresses used to complete the Torus Attached Piping Penetration evaluations in Attachment I remain bounding.

As discussed in Section 2.8 the ECCS Suction Strainer Modification had limited the lower shell corrosion allowance to 0.100 inches to provide additional margin on P_m and $P_L + P_B$ torus shell stress results However, the Corrosion Allowance calculation considered the additional stress resulting from the Strainer Modification and demonstrated acceptability of the 0.143 in corrosion allowance for the lower shell [7.4.19].

5.4 Torus Support System and Attachment Weld Evaluation

The Torus Support System and Attachment Weld Evaluation were performed in Attachment B. The results of the evaluation in Attachment B are summarized below.

5.4.1 Saddle

The saddle load from the Altran 1/16th FEM results for the 0.0 ΔP PS ↓ NO Download phase was used to determine the total load for EC 25: The EC 25 controlling PS load was compared to the TES controlling load [7.4.3 page 21] and determined to be less. Therefore, no further evaluation is required.

The saddle load from the TES 1/32nd FEM results for the 0.0 ΔP PS ↑ Accident Upload phase multiplied by the appropriate Load Condition Adjustment Factor for 0.0 ΔP NO from Section 5.1 was used to determine the total load for EC 25. The controlling PS load was compared to the TES controlling load [7.4.3 page 23] and determine to be less. Therefore, no further evaluation is required as the latest PS ECs do not bound the previously identified controlling EC.

EC 25 0.0 ΔP PS NO ↓

$$= 336 + \sqrt{954^2 + (\sqrt{204^2 + 46^2})^2} = 1313 \text{ kips} < 1604 \text{ kips}$$

EC 25 0.0 ΔP PS NO ↑

$$= -336 + \sqrt{(428 \times 1.05)^2 + \left(\sqrt{146^2 + 46^2}\right)^2} = 139 \text{ kips} < 406 \text{ kips}$$

The TES saddle evaluation is conservative and bounds for 0.0 ΔP PS NO. It demonstrates Code acceptability of the saddle and associated components for continued service at 0.0 ΔP NO.

5.4.2 Inner and Outer Column

The inner and outer torus column supports were analyzed for the controlling EC 25 0.0 ΔP PS ↓ Download Phase during NO in Attachment B. The results listed in Table 18 demonstrate Code compliance for continued service. The EC 25 column loads differed from EC 16 by less than 2%. Therefore, the results are compared against Service Level A Allowable Stress Values to bound EC 16 and EC 18.

Table 18 - Torus Column Axial Plus Bending Stress Ratio for Controlling EC 25 PS ↓Download Phase

Component	Load Direction	Type of Stress	Actual Factor	Allowable Factor	Allowable/ Actual
Inner Column	Down	Axial & Bending	0.69	< 1.0	1.45
Outer Column	Down	Weak Axis Buckling	0.86	< 1.0	1.16

The inner and outer torus column supports, and associated components were analyzed for the controlling EC 25 0.0 ∆P PS ↑ Upload Phase during NO. The results listed in Table 19 demonstrate Code compliance for continued service at 0.0 ∆P NO.

Table 19 - EC 25 PS ↑ Upload Phase for Column Components

Component	Unit	TES Load	TES Allowable	TES Ratio	Adjusted Load	Adjusted Allowable	Adjusted Ratio	Reference
Column Base	kips	128	368	2.88	139	368	2.65	[7.4.3 Page 83 of 175]
Outer Column Base Clamping Plate Anchor Bolts	Bolting Limit kips	58	83	1.43	62.5	83	Concrete Pull-out Controls	[7.4.3 Page 87 of 175]
	Concrete Limit kips	58	65	1.12	62.5	72	1.15	[7.3.2 Para. 3.3.5]
Inner Column Base Clamping Plate Anchor Bolts	Bolting Limit kips	39	83	2.12	42.7	83	Concrete Pull-out Controls	[7.4.3 Page 88 of 175]
	Concrete Limit kips	39	65	1.67	42.7	72	1.69	7.3.2 Para. 3.3.5]
Tie-down Clamping Plate	Bending Stress ksi	19	29	1.53	14.2	29	2.04	[7.4.3 Page 91 of 175]

The results demonstrate a minimum 1.15 margin on Service Level A Code allowable stress value. The Inner and Outer Columns and associated components are acceptable for continued service at 0.0 ∆P NO.

5.4.3 Column to Shell Weld

The results from Attachment B herein are summarized for the bounding Outer Column to Shell Weld Joint. The controlling 0.0 ΔP ↓ Download Phase results are taken from the Altran FEM [7.3.4, Attachment 3]. Drag Loads were taken from the TES 5321-23 Calculation [7.4.3 Pages 106 and 109].

Table 20 - Results for Bounding Outer Column to Shell Weld Stress based on 1/16th Model FEA

Item	Unit	Outer Column Weld	Reference/Calculations
t_{weld}, Web Weld Thickness	in	1.25	[7.4.3 Page 70 of 175]
EC 25 Drag Load at 0.0 ΔP	k/in	0.72	
Drag Stress at 0.0 ΔP	ksi	0.58	0.72 k/in x 1/1.25 in
1/16th FEA N + 0.0 ΔP PS	ksi	9.73	[7.3.4 Page 18]
EC 25	ksi	10.31	(0.58+9.73)
S_U	ksi	70	Material is A516 Gr 70 [7.3.4 Attachment 3 Page 7 of 13]
S_A, Level A Allowable	ksi	21	0.3 S_U x DLF [Section 2.14]
Ratio		2.03	(21/10.33)

The results demonstrate a 2.03 margin on Code allowable stress value. The Inner and Outer Column to Shell Weld Joints are acceptable for continued service at 0.0 ΔP NO.

5.4.4 Saddle to Shell Weld, Clamping Plate and Anchors

The Torus Saddle Clamping Plate and Anchors are controlled by the Upload Phase of the EC 21 (DBACO) reported by TES which is bounding with respect to the 0.0 ΔP PS ↑ Upload Phase loads as demonstrated in Section 5.4.1. The reported values remain unchanged from the TES reported loads with the exception that the allowable bending stress value for the clamping plate is 77,500 psi vs the 75,000 psi reported.

The Torus Saddle Clamping Plate actual load versus the allowable load is 51,700 lbs vs 77,500 lbs based on bounding EC 21.

The results demonstrate a 1.50 margin on Code allowable stress value. The Torus Saddle Clamping Plate is acceptable for continued service at 0.0 ΔP NO as are the associated clamping plate and anchors.

The Saddle to Torus Shell Weld actual stress versus the allowable stress is10.6 vs 21 ksi based on bounding EC 25. The Torus Weld Stress results are taken from the Altran 1/16th model results for EC 25.

The results demonstrate a 1.98 margin on Code allowable stress value. The Saddle to Torus Shell Weld Joint is acceptable for continued service at 0.0 ΔP NO as are the associated clamping plate and anchors.

5.5 Ring Girder Evaluation

5.5.1 RG Flange and Web Stresses

The RG Flange and Web stresses were adjusted for 0.0 ΔP NO using the applicable load condition factors from Table 13 in Section 5.1.

Table 21 - Controlling RG Web and Flange Stress Intensity EC 25 0.0 ΔP PS ↓ Download Phase NO

Stress Intensity	RG Web psi	RG Flange psi	Reference
Total Stress Intensity	17,685	18,480	[7.4.3 Page 135&137 of 175]
Allowable Stress	1.5 S_{MC} = 33,000	S_{MC} = 22,000	[7.4.3 Page 135&137 of 175]
Ratio	1.87	1.19	

The results for the RG web and flange evaluation in Attachment C are provided in Table 21 above. The results demonstrate a 1.19 margin on Code Allowable Stress Value. The RG Web and Flange are acceptable for continued service for 0.0 ΔP NO.

5.5.2 RG Welds

The RG Welds are evaluated in Attachment C. The results for the controlling case, EC 18 are provided below.

Table 22 - RG to Shell Average Weld Load 0.0 ΔP (NO) EC 18 – 1/16th Model Results

RG Weld Location	1/16th Model (N+0.0 ΔP PS) k/in	LOCA Bubble (0.0 ΔP) k/in	Vent Header Support Columns k/in	EC 18 k/in	Allowable k/in	Ratio
Inner Column Region	4.51	0.609 x 1.0= 0.61	0.020 x 1.05 = 0.02	5.14	9.28	1.81
Outer Column Region	5.69	0.341 x 1.0 = 0.34	0.025 x 1.05 = 0.03	6.06	9.28	1.53
Bottom Half RG Region	2.47	2.733 x 1.0 = 2.73	0.926 x 1.05 = 0.97	6.17	9.28	1.50

The bottom portion of the RG weld to the torus shell weld is the controlling area based on the Table 22 results reported above. The results demonstrate a 1.5 margin on Code allowable stress value. The RG to Torus Shell Weld Joint is acceptable for continued service at 0.0 ∆P NO.

5.6 Vent System Evaluation

5.6.1 Vent Header/ Downcomer Intersection

The VH/DC Intersection is evaluated in Attachment D and the stress results are reported in the table below: The two ECs evaluated for 0.0 ∆P PS NO are 18 and 25 which are required to meet Code Service Level B and C, respectively.

Table 23 - Controlling Stress in VH/DC Intersection - 0.0 ∆P NO

EC	0.0 ∆P Actual Stress psi	Allowable Stress psi	Allowable/ Actual
15	35,410	42,900	1.21
18	15,962	42,900	2.69
25	32,509	57,000	1.75

EC15 remains the controlling stress in the downcomer intersection with the lowest Allowable/Actual ratio. The calculated combined maximum stress intensity values meet Code Allowable Stress requirements for EC 15, EC 18 and EC 25. The VH/DC Intersection is acceptable for continued service at 0.0 ∆P NO.

5.6.2 Vent Header/ Vent Pipe Intersection

The VH/VP Intersection is evaluated in Attachment D and the stress results are reported in the table below. The two ECs evaluated for 0.0 ∆P PS NO are 18 and 25 which are required to meet Code Service Level B and C, respectively.

Table 24 - Controlling Stress in VH/VP Intersection - 0.0 ΔP NO

EC	0.0 ΔP Actual Stress psi	Allowable Stress psi	Allowable/ Actual
18	26,885	33,000	1.23
25	26,938	57,000	2.12

The calculated combined maximum stress intensity values meet Code Allowable Stress requirements for EC 18 and EC 25. The VH/VP Intersection is acceptable for continued service at 0.0 ΔP NO.

5.6.3 Vent Header Support Columns and Attachments

The VH Support Columns and Attachments are evaluated in Attachment D and the stress results are reported in the table below. The ECs evaluated for 0.0 ΔP PS NO use a combination of bounding loads from ECs 16, 18 and 25 which are required to meet Code Service Level A to assure bounding results for the three ECs listed above.

Table 25 - Controlling Stress in VH Support Columns and Attachments EC 25 - 0.0 ΔP NO

Structural Element	Stress Type	0.0 ΔP Actual	Allowable	Allowable/ Actual
VH Support Column	Tension	12,097 psi	18,000 psi	1.49
VH Support Column	Bending	2,991 psi	19,800 psi	6.62
VH Support Column	Interaction Ratio	0.82	1.0	1.21
VH Support Column Pin	Bearing	36,968 psi	45,000 psi	1.22

The interaction ratio for the VH Support Column tension plus bending, the VH Support Column Pin bearing and the remaining components listed in Table D- 13 meet Code Allowable Stress requirements for EC 16, EC 18 and EC 25. The VH

Support Columns and Attachments are acceptable for continued service at 0.0 ∆P NO.

5.6.4 Vent Header/ Downcomer Tie-Bars and Attachments

The VH/ Downcomer Tie-Bars and Attachment are evaluated in Attachment D and the stress results are reported in the table below. The EC evaluated for 0.0 ∆P PS NO is ECs 25 which is required to meet Code Service Level A to assure bounding results.

Table 26 - Controlling Stress in VH/ Downcomer Tie-Bars - 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Tie Bar Clamp	25	Bending	12,734 psi	22,240 psi	1.75

The interaction ratio for the VH/ Downcomer Tie-Bar bending stress meets Code Allowable Stress requirements for EC 25 using the Code Service Level A Allowable Stress Value to bound ECs 16 and 18. The VH/ Downcomer Tie-bars and Attachments are acceptable for continued service at 0.0 ∆P NO.

5.6.5 Vent Header Deflector and Attachments

The VH Deflector and Attachments are evaluated in Attachment D and the stress results are reported in the table below. The EC evaluated for 0.0 ∆P PS NO is ECs 25 which is required to meet Code Service Level D.

Table 27 - Controlling Stress in VH Deflector and Attachment - 0.0 ∆P NO

Component	EC (0.0 ∆P)	Type of Stress	Actual	Allowable	Allowable/ Actual
Deflector – Center of the Long Span	25	Membrane + Bending	6,236 psi	63,000 psi	10.10
Attachments – Fillet Weld	25	Shear	24034 psi	35700 psi	1.49

The interaction ratio for the VH Deflector and Attachments Stresses meet Code Allowable Stress requirements for EC 25 using the Code Service Level D Allowable Stress Value. The VH Deflector and Attachments are acceptable for continued service at 0.0 ∆P NO.

5.6.6 Vent Header Main Vent/ Drywell Intersection

The VH Main Vent/ Drywell Intersection is evaluated in Attachment D and the stress results are reported in the table below. The EC evaluated for 0.0 ∆P PS NO is ECs 19 which is required to meet Code Service Level B to assure bounding results.

Table 28 - Controlling Stress in VH Main Vent/ Drywell Intersection - 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Drywell Penetration	19	Membrane + Bending	12,094 psi	33,000 psi	2.73

The interaction ratio for the VH Main Vent/ Drywell Intersection meets Code Allowable Stress requirements for EC 19 using the Code Service Level B Allowable Stress Value. The VH Main Vent/ Drywell Intersection is acceptable for continued service at 0.0 ∆P NO.

5.6.7 Vent Header, Main Vent and Downcomer – Free Shell Stresses

TES established that minimum safety margins would be controlled by local shell stresses such as intersections [7.3.2 Para. 4.4.7]. No further work needs to be done for free shell stress in the structures.

5.6.8 Vent Header Mitre Joint

The VH Mitre Joint is evaluated in Attachment D and the stress results are reported in the table below. The ECs evaluated for 0.0 ∆P PS NO are ECs 18 and 25 which are required to meet Code Service Levels B and C to assure bounding results.

Table 29 - Controlling Stress in VH Mitre Joint - 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Vent Header– Mitre Joint	18	Membrane + Bending	22,357 psi	33,000 psi	1.48
Vent Header– Mitre Joint	25	Membrane + Bending	22,849 psi	57,000 psi	2.50

The interaction ratio for the VH Mitre Joint complies with Code Allowable Stress requirements for ECs 18 and 25 using the Code Service Level B and C Allowable Stress Values respectively. The VH Mitre Joint is acceptable for continued service at 0.0 ∆P NO.

5.6.9 Vent Header – Fatigue Evaluation

The Fatigue results reported by TES in the PUAR are based on Primary + Secondary Stress Range and are unaffected by changes to the PS loading per PUAAG Table 5-2 Note 3 as discussed in Section 2.3.

5.7 T-Quencher

The T-Quencher, Submerged Vertical Piping bounded by the T-Quencher and the VP Penetration and associated T-Quencher Support are evaluated in Attachment E. The stress results are reported in the table below. The EC evaluated for 0.0 ∆P PS NO is EC 25 which is required to meet the Code Service Level B Allowable Stress to assure bounding results as discussed in Section 2.11.2.

Table 30 - Controlling Stresses in T-Quencher, Attached Vertical Piping and Support - 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
T-Quencher Bifurcated Elbow	25	Local Membrane + Bending	26,337 psi	37,920 psi	1.44
Submerged SRV Line Vertical Section Above Reducer	25	Bending	25,298 psi	41,040 psi	1.62
Tee - Quencher Support at the Brace Connection	25	Bending	10,869 psi	48,000 psi	4.42

The interaction ratio for the T-Quencher meets Code Allowable Stress requirements for EC 25 using the Code Service Level B Allowable Stress Values. The T-Quencher, Vertical Pipe to the VP Penetration and associated Support are acceptable for continued service at 0.0 ∆P NO.

Of note, the change in stress of the Vertical Pipe to VP Penetration is from 25,085 psi to 25,298 psi. This represents a negligible increase of less than 1% ($\frac{25{,}298-25{,}085}{25084} \times 100$). The SRV DL blowdown analysis also remains unchanged as discussed in Section 5.10.1 below.

Therefore, the VP penetration evaluation originally completed by TES and those previously evaluated for installation of the 3-Stage Target Rock Valves discussed in Section 2.10.11 remain unchanged for 0.0 ∆P NO.

5.8 Emergency Core Cooling and Reactor Core Isolation Cooling Suction Strainers

The ECCS and RCIC Suction Strainers were upgraded in 1998 as discussed in Section 2.17. The upgrade required reanalysis of the TAP packages as the modification affected all aspects of the original piping analysis. Since the TAP packages were revised to include the upgraded strainers the applicable piping and support results (e.g., Core Tube, Flanges, Supports, Bellows, etc.) were reviewed in the applicable TAP section of Attachment I for 0.0 ∆P NO.

Attachment E discusses the results for the individual strainer components (e.g., perforated plates, stiffeners, welds, etc.).

The R23 modification to add Clamshells to the RHR strainer were also evaluated in Attachments E and I for 0.0 ΔP NO.

- The individual strainer component Actual/ Allowable bounding interaction ratio is 1.16.
- Actual/Allowable interaction ratios are reported for the TAP (and Strainers) in Section 5.10.2.

The ECCS and RCIC Suction Strainers are acceptable for 0.0 ΔP NO.

5.9 Miscellaneous Structures

5.9.1 Catwalk

The Catwalk is evaluated in Attachment G. The stress results are reported in the table below. The EC evaluated for 0.0 ΔP PS NO is EC 25 which is required to meet the Code Service Level E Allowable Stress to assure bounding results.

Table 31 - Controlling Stresses in Catwalk - 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Main Frame	25	Axial +Bending	33,075 psi	56,700 psi	1.71
Support Columns and End Joints	25	Bending	44,968 psi	56,700 psi	1.26
Welds to RG	25	Shear	29,300 psi	42,000 psi	1.43

The interaction ratio for the Catwalk meets Code Allowable Stress requirements for EC 25 using the Code Service Level E Allowable Stress Values developed by TES to prevent formation of a plastic hinge. The Catwalk is acceptable for continued service at 0.0 ΔP NO.

5.9.2 Spray Header

Spray Header Piping Supports and associated Attachment Welds are evaluated in Attachment G. The stress results are reported in the table below. The EC evaluated for 0.0 ΔP PS NO is EC 19 which is required to meet the Code Service Level A Allowable Stress to assure bounding results.

Table 32 - Controlling Stresses in Spray Header, Supports and Attachment Welds - 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Spray Header Piping – Tee at Branch Line	19	Bending	2,686 psi	28,260 psi	10.52
Attachment Welds to RG – Support Hold Down Plate	19	Shear + Bending	16,014 psi	21,000 psi	1.26
Welds to RG	19	Shear + Bending	1,288 psi	21,000 psi	16.30

The interaction ratio for the Spray Header Piping, Supports and associated Attachment Welds meet Code Allowable Stress requirements for EC 19 using the Code Service Level A Allowable Stress Values. Spray Header Piping, Supports and associated Attachment Welds are acceptable for continued service at 0.0 ΔP NO.

5.9.3 Vent Pipe Bellows Displacement Evaluation

The VP Bellows accommodate differential displacement between the Torus and Drywell. The VP Bellows are evaluated in Attachment G. The differential displacement results are reported in the table below. The EC evaluated for 0.0 ΔP PS NO is EC 25 which is required to meet the Bellows Manufacturer's Allowable Displacements to assure bounding results. The allowable displacements are reported by TES in the PUAR [7.3.2 Para. 7.3.3].

Table 33 - VP Bellows Drywell/ Torus Differential Displacements - 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Vent Pipe Bellow	25	Axial Compression	.038 in	.375 in	9.87
Vent Pipe Bellow	25	Axial Extension	.038 in	1.125 in	29.61
Vent Pipe Bellow	25	Lateral Motion	.129 in	.625 in	4.84

The interaction ratio based on the VP Bellows Differential Displacements meet the requirements for EC 25 using the Manufacture's Allowable Differential Displacements. The VP Bellows are acceptable for continued service at 0.0 ΔP NO.

5.9.4 Monorail

The Monorail Beam Supports and associated Attachment Welds are evaluated in Attachment G. The stress results are reported in the table below. The EC evaluated for 0.0 ΔP PS NO is EC 19 which is required to meet the Code Service Level E Allowable Stress to assure bounding results.

Table 34 - Controlling Stress in Monorail Beam, Supports and Attachment Welds - 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Monorail Beam	19	Bending	37,310 psi	42,280 psi	1.13
Monorail Build-up Column	19	Axial + Bending	54,160 psi	57,290 psi	1.06
Monorail Weld to RG	19	Bending + Tension	53,067 psi	57,290 psi	1.08

The interaction ratio for the Monorail Beam, Supports and associated Attachment Welds meet Code Allowable Stress requirements for EC 19 using the Code Service Level E Allowable Stress Values. The Monorail Beam, Supports and associated Attachment Welds are acceptable for continued service at 0.0 ΔP NO.

5.10 Torus Attached Piping

5.10.1 Safety Relief Valve Discharge Lines

As discussed in Sections 2.2, 2.10.11 and 3.2 the SRV DLs were analyzed for the bounding load combination which includes an SBA/ IBA (A1.2) blowdown with a maximum Reflood (C3.3) height due to steam entering the SRV vacuum breaker and rapidly condensing. Since the load combination is bounding, there are no changes for 0.0 ΔP NO. The vertical piping from the VP to the T-Quencher, T-Quencher and associated Support are affected by the Hydrodynamic Loading and they have been addressed in the Attachment E evaluation. The remaining portion of each discharge line and VP Penetration is evaluated separately by JAF for the purpose of installing 3-Stage Target Rock SRVs on each SRV DL. Note that the change in load on the VP Penetration from the Torus Internal Piping, T-Quencher and associated Support is negligible based on the results reported in Attachment E.

5.10.2 TAP Large Bore

Code acceptable results from the review of Large Bore TAP are summarized in the two tables below for the piping and associated torus shell penetrations and nozzle, branch lines, pumps/ valves and supports. The evaluation is performed in Attachment I.

Table 35 - Large Bore TAP Summary Table for Allowable/Actual Ratios

Penetration No.	Pipes	Penetrations	Branch Lines	Pumps/ Valves
X-214	1.52	1.96	2.61	2.00
X-226	1.21	1.36	3.85	1.77
X-212	1.26	1.15	1.31	1.27
X-224	1.80	1.18	6.13	2.96
X-228	1.33	1.28	(1)	2.18
X-205	2.21	1.70	(1)	1.12
X-202B/G	1.47	1.25	(1)	1.52
X-220	2.50	1.70	(1)	1.81
X-210B & X-211B	1.07	1.07	1.16	4.43
X-202A/F	1.54	1.15	(1)	3.49
X-225A & B	1.18	1.45	1.60	1.18
X-227A	1.33	1.24	2.33	1.41
X-227B	1.32	1.19	2.17	1.12
X-210A & X211A	1.27	1.12	1.88	3.54
X-213A/B	1.32	1.10	(1)	0.94 (2)

Table Notes:

1. No branch lines are reported by TES for the piping associated with this penetration.
2. Based on TES, Penetration X-213A/B is a torus drain line and is not used during plant operation; therefore, the valve does not have to meet the 1.2 S_H allowable stress value [7.4.53 Page 8 of 8].

Table 36 - Large Bore TAP Support Summary Table Ratios

Penetration No.	Pipe Supports
X-214	The controlling Allowable/ Actual ratio is 1.14.
X-226	The increase in support loads by 11% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-212	The 0.0 ΔP PS NO ECs are bounded by the DBACO RMS for the support evaluation.
X-224	The increase in support loads by 11% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-228	The increase in support loads by 11% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-205	The 0.0 ΔP NO ECs, are bounded by the DBACO RMS for the support evaluation.
X-202B/G	The increase in support loads by 11% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-220	PS is relatively small compared to SRV and SSE. The change in dynamic loading from 1.7 ΔP NO to 0.0 ΔP NO is negligible when included in the ECs.
X-210B & X-211B	The increase in support loads by less than 10% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-202A/F	The increase in support uploads by 5% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-225A & B	The bounding pipe support interaction ratio is 1.08 including both Torus internal and external supports.
X-227A	The bounding pipe support interaction ratio is 1.14 including both Torus internal and external supports.
X-227B	The bounding pipe support interaction ratio is 1.10 including both Torus internal and external supports.
X-210A & X211A	The increase in support loads by less than 10% is bounded by the 1/3 increase in Allowable Stress Value from Level A to Level B.
X-213A/B	The 0.0 ΔP PS NO ECs, are bounded by the CH EC for the support evaluation.

5.10.3 TAP Small Bore

Code acceptable results from the review of Small Bore TAP are summarized in the table below for the piping and associated torus shell penetration and nozzle, and valves. The evaluation is performed in Attachment I.

Table 37 - Small Bore TAP Summary Table for Maximum Allowable/ Actual Ratios

Penetration No.	Pipes	Penetrations	Valves
X-203B	3.48	7.57	1.71

X-206 A, B, C & D X-206 A1/2 X-206 B1 X-206 C1/2 X-206 D1 X-248 A, B & C	1.50	7.57	1.31
X-221, X-217	1.92	14.0	2.05
X-222	2.10	14.0	1.21

5.11 Summary of Structural Element and TAP Review

The Table 38 below contains a summary of the Allowable to Actual Ratios for the Structural Elements and Torus Attached Piping. The minimum ratio is 1.06.

Table 38 – Controlling Allowable/ Actual Ratio for Structural Elements - 0.0 ΔP NO

Structural Elements and TAP	Event Combination	Major Load Condition	Ratio: Allowable/ Actual	Report Summary Section
Torus Free Shell Stress	20	DBACO	1.14	5.3
Inner/Outer Column Clamping Plate	25	PS	2.00	5.4.2
Column/ Torus Shell Weld	25	PS	2.03	5.4.3
Saddle Clamping Plate	21	DBACO	1.50	5.4.1
Saddle/ Torus Shell Weld	25	PS	1.13	5.4.4
RG Flange & Web Stress	25	PS	1.19	5.5.1
RG Welds	18	PS	1.50	5.5.2
VH/DC Intersection	15	IBACO	1.21	5.6.1
VH/ VP Intersection	18	PS	1.23	5.6.2
VH Support Columns	25	PS	1.21	5.6.3

Structural Elements and TAP	Event Combination	Major Load Condition	Ratio: Allowable/ Actual	Report Summary Section
VH/DC Tie-Bars	25	PS	1.75	5.6.4
VH Deflector	25	PS	1.49	5.6.5
Main Vent/ Drywell Intersection	19	PS	2.73	5.6.6
VH Mitre Joint	18	PS	1.48	5.6.8
T-Quencher	25	PS	1.44	5.7
ECCS & RCIC Strainers	25	PS	1.16	5.8
Catwalk	25	PS	1.26	5.9.1
Spray Header	19	PS	1.26	5.9.2
VP Bellows	25	PS	4.84	5.9.3
Monorail	19	PS	1.06	5.9.4
SRV DL			(1)	5.10.1
Large Bore TAP	25	PS	1.07	5.10.2
Small Bore TAP	25	PS	1.21	5.10.3

Table Notes:

1. SRV DLs were not affected by the change to 0.0 ΔP NO as a more bounding SRV Blowdown EC was analyzed.
2. The EC summarized for the Small Bore TAP is EC 25. However, EC 21 was originally used by TES. The DBACO load condition was determined to be bounding of all other plant load conditions including the 0.0 ΔP PS Accident Condition. SRV loads on the Small Bore TAP are negligible when SRSS'd with EQ and DBA CO. Therefore, DBA CO was taken as the 0.0 ΔP PS NO load condition when increased by the Load Condition Adjustment Factor of 1.11 [Section 5.1].

6.0 CONCLUSIONS AND RECOMMENDATIONS

An updated summary of the Structural Elements and Torus Attached Piping results evaluated during the Mk I Program by TES and recently revised by Imperia Engineering Partners is contained on Table 38 – Controlling Allowable/ Actual Ratio for Structural Elements - 0.0 ΔP NO. The update demonstrates acceptability of all Structural Elements and TAP for continued service of the JAF NPP at a Drywell-to-Wetwell differential pressure of 0.0 psid during Normal Operation (i.e., 0.0 ΔP NO). Table 38 demonstrates that all Structural Elements and TAP meet Code requirements at the current torus water level and submergence.

The JAF Team did not make a decision with respect to increasing the submergence for 0.0 ΔP NO prior to the issuance by Imperia of this TR Revision 0. Revision 0 was reviewed by the JAF Team, and comments incorporated prior to acceptance. However, the TR was not entered into the Exelon Document Control System pending the results of the R23 RHR ECCS Suction Strainer modification. The decision on submergence was also tabled at that time.

Upon successful completion of the R23 ECCS Suction Strainer modification, GEH successfully completed a Short Term Transient analysis to demonstrate Mk I Program compliance for 0.0 ΔP NO. In addition, the JAF Team decided that a 3” increase in torus water level shall be implemented to provide additional Operator flexibility. The decision was based in part on available margin demonstrated by the interaction ratios provided in Table 38 – Controlling Allowable/ Actual Ratio for Structural Elements - 0.0 ΔP NO and the discussion in Section 5.2.2 and Table 14 - Load Condition Adjustment Factors for +3” Increased Submergence. The controlling ratio is 1.07 and in addition a ratio of 1.056 is required to implement the +3” submergence. Therefore, remaining minimum margin is 1.014 (1.07 - 1.056).

This effort also reconciled use of later ASME Code Editions for the Structural Elements and Torus Attached Piping evaluation as discussed in Section 2.12.

Based on the reported results, Imperia Engineering Partners recommends that Exelon/ JAF NPP pursue an Industry Standard Engineering Change Modification Package with Technical Specification Amendment to allow 0.0 ΔP NO including a +3.0 inch Submergence change to 14.25 ft.

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7.5. Codes and Standards

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7.5.7. American Society of Mechanical Engineers, USA Standard Code for Pressure Piping B31.1.0, "Power Piping," 1967 Edition with Equations from ANS 1973 Summer Addenda.

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7.5.9. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Vessels," 1965 Edition with 1966 Winter Addenda.

7.5.10. American Institute of Steel Construction, "Manual of Steel Construction," 7th Edition, June 1970.

7.5.11. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section II, "Materials, Part C Specifications for Welding Rods, Electrodes and Filler Metals," 2007 Edition through 2008 Addenda.

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7.5.13. Bergen – Paterson Catalog No. 77NFR, "Nuclear Service," Laconia, NH 03246.

7.6. JAF Design/ Licensing Bases Documents

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Note: *Section 1.2.3 As applicable for each site, ASME Section XI, 2001 Edition through 2003 Addenda, 2004 Edition, or 2007 Edition through 2008 Addenda shall be utilized for repairs/replacement activities of pressure retaining components which are classified as Class MC and CC, including their integral attachments.*

7.6.2. Exelon – James A. FitzPatrick, "Technical Specification LCO," Docket Number 50-333.

Note: *Amendment .317, On the specific temperature/water level pages are 3.6.2.1-1 through 3 and 3.6.2.2.*

7.6.3. Exelon – James A. FitzPatrick, "Updated Final Safety Analysis Report," 2017 Submittal, Rev.006.

Note: Section 12.5.1.3 Suppression Chamber describes the Mk I Program and NRC acceptance by the NUREG-0661, Safety Evaluation Report.

Note: *Section 12.5.1.3 JAF utilized American Institute of Steel Construction (AISC) Code requirements as structural acceptance criteria for pipe support*

design instead of ASME Code Section III, 1977 Edition through Summer 1978 Addenda for Torus Attached Piping (TAP) supports and SRV piping supports (Phase III modifications), since it was the original design code for the pipe supports at JAF.

Note: *Section 16.2.3.1 ANSI B31.1.0 - 1967 Code for Power Pressure Piping.*

7.7. JAF Drawings

7.7.1. Entergy JAF Drawing No. 3.77-5, “Suppression Chamber Support Girder and Vent Header Support - Field Ass'y”, CBI Drawing No. 302, Rev. 4, Feb. 2008.

7.7.2. Entergy JAF Drawing No. 3.83-11, “Walkway Platform and Monorail Removal Details”, Teledyne Drawing No. D-5646, Rev. 2, Jan. 1982.

7.7.3. Entergy JAF Drawing No. 3.83-12, “Reinforcement for Existing Walkway”, Teledyne Drawing No. D-5669, Sheet 1 of 3, Rev. 3, Jan. 1982.

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7.7.7. Entergy JAF Drawing No. FV-1J, “Drywell and Suppression Chamber Penetration Location and Details”, Sheet 2, Rev 013, Jan. 2007.

7.7.8. Entergy JAF Drawing No. FK-1C, “Instrumentation Piping Reactor Building”, Sheet 3, Rev 012, Jan. 2014.

7.7.9. Entergy JAF Drawing No. FK-1D, “Instrumentation Piping Reactor Building”, Sheet 4, Rev 017, Nov. 2008.

7.7.10. Entergy JAF Drawing No. FK-4D, “Instrument Piping Level Control and Switch”, Sheet 4, Rev 017, Jan. 1997

7.7.11. James A FitzPatrick Drawing No. 3.72-16, “Torus Support Column Baseplate Tiedown Assembly,” Rev A, December 1985.

A. TORUS SHELL EVALUATION FOR 0.0 ΔP NORMAL OPERATION

The FitzPatrick Torus Shell Analysis provided in TES Calculation 5321-20 and PUAR TR-5321-1 listed the Torus Shell Stress results and associated bounding ECs that are provided in Table A-1 to facilitate document review [7.4.5 Section IV Torus Shell Stress Summarization Page 155, & 7.3.2 Section 3.3 Results and Evaluation Para. 3.3.1]:

Table A-1 - Torus Shell Controlling Event Combinations

Stress Intensity	Location (Figure A-1)	EC	Stress Intensity psi	1977 Code Allowable psi	Reconciled Allowable psi	Allowable/ Actual
P_m	Free Shell Element 17	EC 20 (DBACO)	13,776	1.0 S_{MC} = 19,300	22,000	1.60
P_L	Local Shell Element 160	EC 14 (IBACO)	8,807	1.5 S_{MC} = 28,950	33,000	3.75
$P_L + P_B$	Free Shell Element 19	EC 20 (DBACO)	14,146	1.5 S_{MC} = 28,950	33,000	2.33
$P_L + P_B + Q$ Alternating Stress	Local Shell Element 148	EC 14 (IBACO)	27,895	3.0 S_{M1} = 69,900	69,900	2.51

The information provided in the Table was post processed by the DISTRES program which took the results of each Load Condition analysis on the 1/32nd Torus Model, performed the EC evaluation and provided the results (See Section 2.9).

The component stress results at the top and bottom of the Free Shell Elements 17 and 19 were taken directly from the DISTRES computer output. They are listed on the following pages. In addition, the P_M and P_L+P_B stress intensity values were calculated for the bounding ECs for 1.7 ΔP PS ↓ and 0.0 ΔP PS ↓ NO. The 1.7 ΔP PS ↓ EC 18 and 25 cases were compared successfully with the DISTRES output.

ELEMENT 17 – EC 18 1.7 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DW	1638	595	-29	1725	960	-45
OBE	106	217	12	108	218	12
1.7 ∆P PS ↓	2947	1502	-20	2479	1224	-2
Stress Total	4691	2314	-37	4312	2402	-35
Membrane (M)	4502	2358	-36			
Bending (B)	190	44	1			
M+B	4691	2402	-37			
P_M	4502	2357	2145			
P_M+P_B	4692	2401	2290			

ELEMENT 17 – EC 18 0.0 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DW	1638	595	-29	1725	960	-45
OBE	106	217	12	108	218	12
0.0 ∆P PS DN	6759	3200	-137	6821	2877	-118
0.0 ∆P PS ↓ x 1.11	7502	3552	-152	7571	3193	-131
ST	9246	4364	-169	9404	4371	-164
M	9325	4368	-167			
B	79	4	3			
M+B	9404	4371	-169			
PM	9331	4362	4969			
PM+PB	9410	4366	5044			

ELEMENT 17 – EC 25 1.7 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1638	595	-29	1725	960	-45
SSE	178	405	22	183	406	23
SRV D	-932	-511	3	-975	-505	-1
SRV U	1333	878	-47	1366	868	-51
1.7 ∆P PS ↓	2947	1502	-20	2479	1224	-2
ST1	3831	1991	-24	3412	2085	-25
ST2	6096	3380	-74	5753	3458	-75
M1	3622	2038	-25			
M2	5925	3419	-75			
B1	210	47	1			
B2	172	39	1			
M1+B1	3831	2085	-25			
M2+B2	6096	3458	-75			
PM1	3622	2038	1584			
PM2	5927	3417	2510			
PM1+PB1	3831	2085	1747			
PM2+PB2	6098	3456	2642			

ELEMENT 17 – EC 25 0.0 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1638	595	-29	1725	960	-45
SSE	178	405	22	183	406	23
SRV D	-932	-511	3	-975	-505	-1
SRV U	1333	878	-47	1366	868	-51
0.0 ∆P PS ↓ x 1.11	7502	3552	-152	7571	3193	-131
ST1	8386	4041	-156	8504	4054	-154
ST2	10651	5430	-206	10845	5427	-204
M1	8445	4048	-155			
M2	10748	5429	-205			
B1	59	7	1			
B2	97	1	1			
M1+B1	8504	4054	-156			
M2+B2	10845	5430	-206			
PM1	8451	4042	4409			
PM2	10756	5421	5335			
PM1+PB1	8510	4049	4461			
PM2+PB2	10853	5422	5431			

ELEMENT 19 – EC 18 1.7 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1689	454	30	1786	952	8
OBE	104	211	14	103	214	14
1.7 ∆P PS ↓	2222	832	27	3079	1058	14
ST	4015	1497	71	4968	2224	36
M	4492	1861	54			
B	477	364	18			
M+B	4968	2224	71			
PM	4493	1859	2633			
PM+PB	4970	2222	2748			

Attachment A – Torus Shell Evaluation for 0.0 ∆P Normal Operation

ELEMENT 19 – EC 18 0.0 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1689	454	30	1786	952	8
OBE	104	211	14	103	214	14
0.0 ∆P PS DN	6925	2906	42	6991	2609	39
0.0 ∆P PS ↓ x 1.11	7687	3226	47	7760	2896	43
ST	9480	3891	91	9649	4062	65
M	9564	3976	78			
B	85	86	13			
M+B	9649	4062	91			
PM	9565	3975	5590			
PM+PB	9650	4061	5590			

ELEMENT 19 – EC 25 1.7 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1689	454	30	1786	952	8
SSE	174	353	26	173	399	27
SRV D	-964	-564	11	-880	-511	10
SRV U	1438	853	43	1299	775	51
1.7 ∆P PS ↓	2222	832	27	3079	1058	14
ST1	3121	1075	94	4158	1898	59
ST2	5523	2492	126	6337	3184	100
M1	3640	1487	77			
M2	5930	2838	113			
B1	519	412	18			
B2	407	346	13			
M1+B1	4158	1898	94			
M2+B2	6337	3184	126			
PM1	3642	1484	2158			
PM2	5934	2834	3100			
PM1+PB1	4162	1894	2268			
PM2+PB2	6342	3179	3163			

ELEMENT 19 – EC 25 0.0 ∆P NO Stress psi						
Location	Top			Bottom		
Component	S_X	S_Y	S_{XY}	S_X	S_Y	S_{XY}
DWT	1689	454	30	1786	952	8
SSE	174	353	26	173	399	27
SRV D	-964	-564	11	-880	-511	10
SRV U	1438	853	43	1299	775	51
0.0 ∆P PS ↓ x 1.11	7687	3226	47	7760	2896	43
ST1	8586	3469	114	8839	3736	88
ST2	10988	4886	146	11018	5022	129
M1	8712	3602	101			
M2	11003	4954	137			
B1	127	134	13			
B2	15	68	8			
M1+B1	8839	3736	114			
M2+B2	11018	5022	146			
PM1	8714	3600	5114			
PM2	11006	4951	6055			
PM1+PB1	8842	3733	5108			
PM2+PB2	11022	5018	6003			

The controlling EC 18 & 25 NO results for 1.7 ∆P and 0.0 ∆P are provided in Table A-2. A comparison to of the 0.0 ∆P EC 18 and 25 with the P_M and P_L+P_B results to those listed in Table A-1 indicates that the original controlling ECs still bound the 0.0 ∆P NO Stress Intensity values listed in Table A-2.

Table A-2 - Controlling ECs 18 and 25

Element NO	EC 18 P_M psi		EC 18 P_L+P_B psi		EC 25 P_M psi		EC 25 P_L+P_B psi	
	1.7 ∆P	0.0 ∆P	1.7 ∆P	0.0 ∆P	1.7 ∆P	0.0 ∆P	1.7 ∆P	0.0 ∆P
17	4502	9331	4692	9410	5927	10756	6098	10853
19	4493	9565	4970	9650	5934	11006	6342	11022

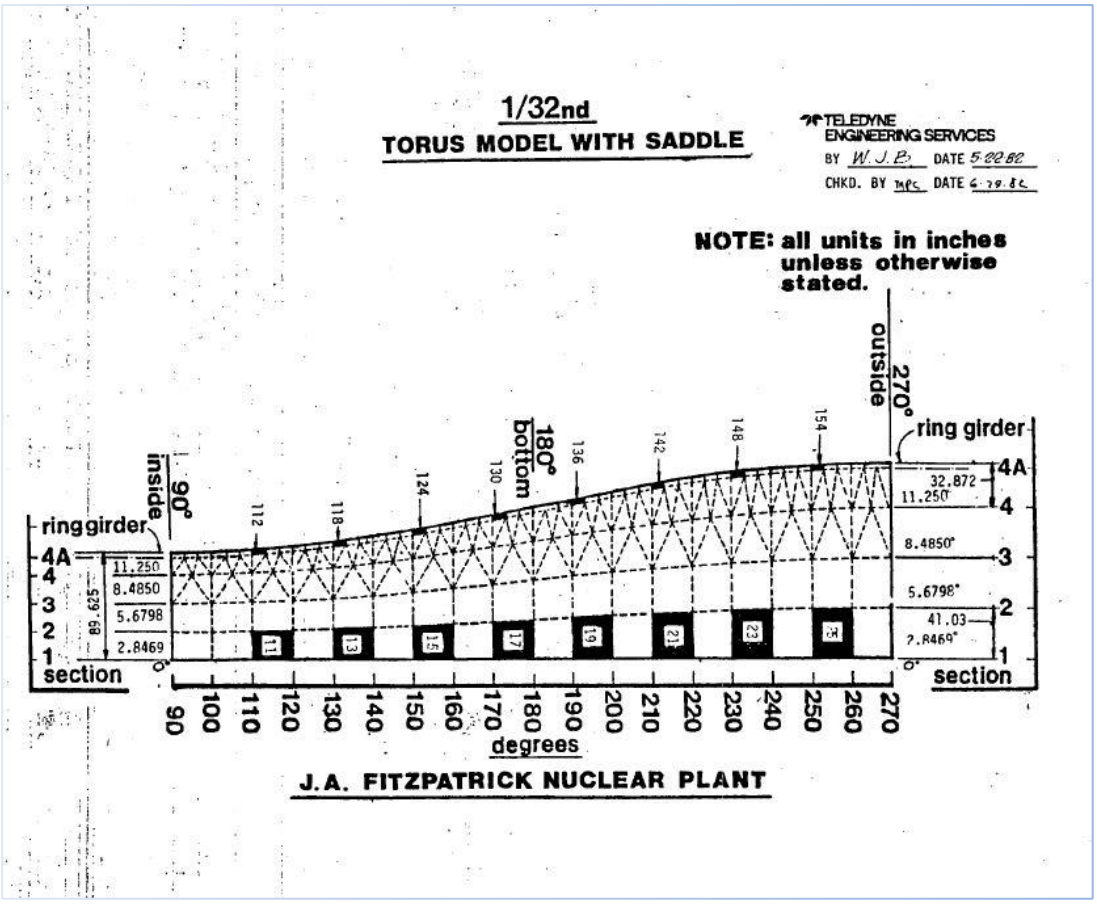

Figure A-1 Shell Element Location for 1/32nd Model by TES [7.4.5 Page 17 of 234]

B. TORUS COLUMN, SADDLE AND ASSOCIATED WELD EVALUATION FOR 0.0 ΔP NORMAL OPERATION

Torus Support Columns and Column to Shell Weld Stress Evaluation

The Torus Support system consists of the Inner and Outer Columns plus the Saddles and associated weld joints to the Torus Shell. The columns consist of the upper weld joint and reinforcement plates welded to the shell and the baseplate and anchors to the concrete. The saddle also has a weld joint to the shell and a baseplate with anchors to the concrete. Two cases are considered herein, one for the PS ↓ Download Phase and one for the PS ↑ Upload Phase at 0.0 ΔP NO.

The PS Download Phase was analyzed during the scoping phase of this project and results are summarized in the accompanying Altran Draft Report [7.3.4] and Table B-1 below. As discussed in Section 2.5 the distribution of the Download Phase between the columns and saddle changed due to the modeling refinements. Therefore, the refined Altran 1/16th Model load is used for the 0.0 ΔP PS ↓ Download phase. The 1/16th model also included the applicable load condition adjustment factor. The remaining PS ↓ Download phase Load Conditions are taken from the TES 1/32nd model results as reported in Calculation: FitzPatrick Torus Saddle Analysis," 5321-23 R0, October 1982 [7.4.3]. Note: that the 1/32nd results are multiplied by a factor of 2 to obtain an equivalent symmetric 1/16th of the Torus (i.e., ½ of a vent plus non-vent bay).

The 0.0 ΔP NO PS ↑Upload Phase was not analyzed during the scoping phase of this project and all column and saddle load results are taken from the TES Torus Saddle Analysis Calculation referenced above.

The Load Condition Adjustment factors [Section 5.1] are used with the 1/32nd TES Download and Upload Phase Column and Saddle results.

Weld joints were reviewed during the scoping phase and reported in the Altran Draft Report. However, the weld joint loading was incomplete at that time as it did not include submerged structure loading as the margin was adequate to demonstrate a success path forward. The loading reported herein for the Weld Joints includes the applicable submerged structure loading with Section 5.1, "Load Condition Adjustment Factors".

Table B-1 - Comparison of FEM PS Download Phase Reaction Loads (Kips)

Model	Inner Column	Outer Column	Saddle	Total	References
TES 1/32nd	270	300	1,267	1,837	2x0.0 ΔP PS Accident ↓ for comparison to 1/16th FEM [7.4.3 Page 21 of 175]
Altran 1/16th	381	480	954	1,815	[7.3.4, Not Reported but calculated to valid the FEA]

Saddle Evaluation

Saddle 0.0 ΔP PS ↓ NO reaction loads from the 1/16th Model FEA and the 0.0 ΔP PS ↓ Accident Condition 1/32nd Model FEA are 954 kips and 1,267 kips, respectively. The difference in load distribution for the PS Download phase between the two models results from the modeling refinements and the application of both vent and non-vent bay PS pressure loads versus scaling of non-vent bay results [Section 2.5].

The saddle Download phase was analyzed by TES for the bounding EC 16, 0.0 ΔP ↓ Accident Condition. The saddle Upload phase was analyzed by TES for the bounding EC 21 DBA CO [7.4.3 Pages 21 & 23 of 175]

Table B-2 - TES Saddle Loads Bounding Event Combinations/ Load Conditions

Event Combination 1/32nd Factored by 2	Load Condition	Saddle Download Phase kips	Saddle Upload Phase kips
15 (N+SRV+EQ+IBA CO)	IBA CO	716	-16
21 (N+EQ+DBA CO)	DBA CO	1080	406
16 (N+0.0 ΔP PS)	0.0 ΔP PS Accident	1604	90
25 (N+1.7 ΔP PS+SRV+EQ)	1.7 ΔP PS Accident	978	32

Load Condition 1/32nd Factored by 2	Saddle Download Phase kips	Saddle Upload Phase kips
N (Weight)	336	336
SRV	204	146
EQ	46	46
DBA CO	696	696
0.0 ΔP PS Accident	1267	428
1.7 ΔP PS Accident	470	234

The controlling EC for the saddle for 0.0 ΔP PS NO will be EC 25 as discussed in Section 2.11.1. Noting the following for preparation of EC 25 for both the Download and Upload Phases:

1. EC 25 Load Condition dynamic loads for the Saddle (SRV + EQ) are SRSS'd and then SRSS'd with PS consistent with the TES calculated results [7.4.3 Pages 21 & 23 of 175].
2. 0.0 ΔP PS NO ↑ is obtained by using 0.0 ΔP PS accident ↑ and the Load Condition Adjustment Factor of 1.05 from Table 13. Section 5.1.
3. The 0.0 ΔP PS NO ↓ is taken from Table B-1. The other loads are taken from Table B-2 above.

EC 16 0.0 ΔP PS NO ↓ $= 336 + 954 = 1290\ kips < 1604\ kips$

EC 18 0.0 ΔP PS NO ↓ $= 336 + \sqrt{954^2 + 46^2} = 1291\ kips < 1604\ kips$

EC 25 0.0 ΔP PS NO ↓ $= 336 + \sqrt{954^2 + (\sqrt{204^2 + 46^2})^2} = 1313\ kips < 1604\ kips$

EC 25 0.0 ΔP PS NO ↑ $= -336 + \sqrt{(428 \times 1.05)^2 + \left(\sqrt{146^2 + 46^2}\right)^2} = 139\ kips < 406\ kips$

The results of 1/32nd Model for saddle and saddle components meet ASME Code allowable stress values. The lowered results reported above based on the Phase I FEA for EC 25 0.0 ΔP PS NO demonstrate acceptability for continued service. It is also noted, that the SRV and SSE loading is negligible with respect to the reported results ((1313 – 1290)/1290 x 100 = < 2%) [Section 2.15]

Torus Column Download Phase

The 0.0 ΔP P.S. ↓ NO controlling ECs 18 and 25 for the columns based on refined 1/16th Model FEA by Altran are summarized below in Table B-3. Normal load was also taken from the 1/16th FEM results. Seismic and SRV load are taken from the TES 1/32nd FEM [7.4.3]. The summarized loads will be used for the evaluation of the Torus Support Column and associated components. The EC Load Conditions are combined similarly to the EC 25 Saddle Load described above. Moment loads used to calculate bending stress about the strong and weak column axes on the outer column were taken from the Altran FEA results at the outer column to shell weld consistent with the TES results reported in Saddle Analysis [7.4.3 Page 81 of 175]. These same moments were conservatively used for the more lightly loaded inner column.

Table B-3 - Torus Column 0 ΔP PS NO Download based on 1/16th Model FEA

Loads/Ratios	Unit	Inner Column	Outer Column	Reference
0.0 ΔP PS ↓ + N	lbs	381,260	480,440	1/16th Model FEA Results [7.3.4] Not Reported but calculated to validate the FEA
Normal Load, N	lbs	95,190	113,180	1/16th Model FEA Results [7.3.4] Not Reported but calculated to validate the FEA
Seismic, SSE	lbs	6,854	15,554	2x0.0 ΔP PS Accident ↓ for comparison to 1/16th FEM [7.4.3 Page 21 of 175]
SRV	lbs	23,458	14,836	2x0.0 ΔP PS Accident ↓ for comparison to 1/16th FEM [7.4.3 Page 21 of 175]
EC 16 = N + P_{ps}	lbs	476,450	593,620	
EC 18 = N + P_{ps} + SSE	lbs	476,512	593,872	
EC 25 = N + P_{ps} + SRV + SSE	lbs	477,232	594,100	

Support Column Axial Condition

The FitzPatrick Torus Saddle Analysis Calculation and PUAR listed the column stress factor provided in Table B-4 below based on 1/32nd Model FEA [7.4.3 Page 77 of 175 & 7.3.2 Para. 3.3.2]. The column sections are W12x161. Column and baseplate material is A36. The reinforcing plates are A516 GR.70 [7.4.3 Page 80 of 175 and 7.7.11 Drawing].

Table B-4 - Torus Column Stress Reported by Teledyne

Component	Load Direction	Type of Stress	Actual Factor	Allowable Factor
Inner Column	Down	Axial & Bending	.55	1.0
Outer Column	Down	Axial & Bending	.65	1.0

Table Notes

1. [7.4.3 Page 77 of 175 & 7.3.2 Para. 3.3.2]

Weak/ Minor Axis Column Buckling

The inner and outer columns supporting the JAF torus are welded to the saddle plate. This provides the columns with a continuous lateral support about the column strong/ major axis. The moments about the minor axis are negligible [7.4.3 Page 77 of 175]. The difference in inner and outer column load for ECs 16, 18 and 25 is small. Therefore, the EC 25 load will be used to calculate results for the columns and associated components. These results will be compared to the EC 16 Service Level A allowable stress values. Column and reinforcement materials are A36 and A516 Gr 70 therefore A36 properties and allowable stress values are used for the evaluation [7.4.3 Page 81 of 175].

For the minor axis column buckling, it requires the following equations [7.4.3 Page 78 of 175].

$$\frac{f_a}{F_a} + \frac{C_m f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} + \frac{C_m f_{by}}{\left(1 - \frac{f_a}{F'_{ey}}\right) F_{by}} \le 1.0$$

EQ. 20
REF. 9

$$\frac{f_a}{.6 F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \le 1.0$$

EQ 21
REF. 9

Since the moments about the strong axes are laterally supported and the moments about the minor axes are negligible, the equations can be reduced to the following [7.4.3 Page 78 of 175].

EQ. 20 : $\frac{f_a}{F_a} \le 1.0$, EQ. 21 : $\frac{f_a}{.6 F_y} \le 1.0$

Table B-5 - Buckling Loads along Minor Axis for Torus Support Columns

Item	Unit	Inner Column	Outer Column	Reference
Yield Strength, F_y	ksi	36.0	36.0	[Section 2.13, Table 11]
F_a	ksi	14.61	14.61	[7.4.3 Page 78 of 175]
A, Column Section Area	in^2	47.4	47.4	[7.4.3 Page 78 of 175]
EC 25				
Load, P (EC 25)	kips	477	594	[Table B-3]
$f_a = P/A$	ksi	10.1	12.5	
f_a/F_a	-	0.69	0.86	< 1.0
$f_a/0.6F_y$	-	0.47	0.58	< 1.0

Review of the buckling results for the inner and outer columns demonstrates Code acceptability of the columns with respect to the Column Buckling load.

Major Axis Column Stress

Column stresses about the major axis were calculated based on the EC 25 as listed in Table B-6. The Seismic and SRV contributions to the loading are very small therefore EC 25 is used along with Service Level A Allowable Stress Values to bound EC 16 and EC 18.

Table B-6 - Column Stresses about Major Axis – EC 25

Item	Unit	Inner Column	Outer Column	*Reference*
EC 25 P = N+P_{PS}+SSE	kips	477	594	[Table B-3]
A, Column Section Area	in^2	47.4	47.4	[7.4.3 Page 78 of 175]
S_{xx}, Section Modulus about X	in^3	222	222	[7.4.3 Page 81]
S_{yy}, Section Modulus about Y	in^3	77.7	77.7	[7.4.3 Page 80]
M_y, Bending Moments	in-kips	163.3	163.3	1/16th Model FEA Results [7.3.4] Not Reported but calculated to valid the FEA. Outer Column Results used for Inner Column
M_x, Bending Moments	in-kips	238.3	238.3	1/16th Model FEA Results [7.3.4] Not Reported but calculated to valid the FEA. Outer Column Results used for Inner Column
f_a=P/A	ksi	10.1	12.5	
M_y/S_{xx}	ksi	0.74	0.74	
M_x/S_{yy}	ksi	3.1	3.1	
Combined Stress, P/A+M_y/S_{xx}+M_x/S_{yy}	ksi	13.9	16.3	
S_y, Yield Stress	ksi	36.0	36.0	[Section 2.13 Table 11]
S_a, Allowable Stress	ksi	21.6	21.6	0.6*S_y
Combined Stress/Allowable		0.64	0.75	< 1.0

Both inner column and outer columns are adequately supported for the applied 0.0 ΔP PS ↓ Download phase from controlling EC 16, EC 18 and EC 25. It is also noted, that the combined SRV and SSE loading are negligible with respect to the reported results ((477.2– 476.5)/476.5 x 100 = < 1%) [Section 2.15].

<u>Torus Column Upload Phase</u>

The scoping phase of this project did not evaluate the ↑ Upload PS Phase using the 1/16th FEM as no issues were identified during the review that was performed prior to the scoping phase. Therefore, the calculated 0.0 ΔP PS ↑ Upload from the accident condition evaluated by TES are increased by the Load Condition Adjustment Factor of 1.05 [Section 5.1] for NO at 0.0 ΔP. The affected components include the

Inner and Outer Column Base, Anchors and Tie-down plates. The outer column has the largest loads because of the Torus Geometry as the tributary area of the Torus Shell is greater.

Table B-7 - TES Calculated Event Combinations for PS ↑ Upload Phase

Event Combination	Inner Column kips	Outer Column kips
15	-10	-12
21	37	45
16	87	128
25	44	70

Table Notes:

1. Reference is TES Calculation 5321-23 [7.4.3 Page 25 of 175]

Using the Load Conditions from the 1/32nd FEM listed on Page 23 and doubling them the following are the new column loads for EC 25.

Inner Column

EC 25 0.0 ∆P PS NO ↑ $= -68 + \sqrt{(154\ \times 1.05)^2\ + \left(\sqrt{16^2 + 7^2}\right)^2}\ =\ 95\ kips > 87\ kips$

Outer Column

EC 25 0.0 ∆P PS NO ↑ $= -76 + \sqrt{(204\ \times 1.05)^2\ + \left(\sqrt{13^2 + 16^2}\right)^2}\ =\ 139\ kips > 128\ kips$

Table B-8 - Controlling Load Comparison for PS ↑ Upload Phase

Column	TES Controlling Load kips	0.0 ∆P PS ↑ NO EC 25 Load kips	Load Ratio
Inner	87	95	1.09
Outer	128	139	1.09

Table Notes:

1. The inner and outer columns have two clamping plates (i.e., one on each side) that are secured to the concrete with 2 concrete anchors each for a total of 4 anchors [7.7.11]
2. The individual bolts are rated for 85 kips based on material properties [7.4.3. Pages 87 – 90 of 175]
3. The individual bolts are rated for 65 kips based on concrete strength.
4. 128 kips of upward column load on a single clamping plate results in approximately 58 kips per bolt due to the clamping plate offset moment. [7.4.3. Pages 87 – 90 of 175].

Table B-9 - EC 25 PS ↑ Upload Phase for Column Components

Component	Unit	TES Load	TES Allowable	TES Ratio	Adjusted Load/ Stress	Adjusted Allowable	Adjusted Ratio	Reference
Column Base	kips	128	368	2.88	139	368	2.65	[7.4.3 Page 83 of 175]
Outer Column Base Clamping Plate Anchor Bolts	Bolting Limit kips	58	83	1.43	62.5	83	Concrete Pull-out Controls	[7.4.3 Page 87 of 175]
	Concrete Limit kips	58	65	1.12	62.5	72	1.15	[7.3.2 Para. 3.3.5]
Inner Column Base Clamping Plate Anchor Bolts	Bolting Limit kips	39	83	2.12	42.7	83	Concrete Pull-out Controls	[7.4.3 Page 88 of 175]
	Concrete Limit kips	39	65	1.67	42.7	72	1.69	7.3.2 Para. 3.3.5]
Tie-down Clamping Plate	Bending (ksi)	19	29	1.53	14.2	29	2.04	[7.4.3 Page 91 of 175]

Table Notes:

1. Reference Calculation is TES 5321-23, FitzPatrick Torus Saddle Analysis (Pages 88-91 of 175) and Drawing Number 3.72-16, Torus Support Column Baseplate Tiedown Assembly [7.4.3 & 7.7.11]
2. The TES allowable column bolt load of 65 kips is based on the 4000 psi concrete compressive strength and calculated using a safety factor of 4.
3. The TES allowable column bolt load based on concrete compressive strength also accounts for anchor bolt embedment depth (18.75”) and shear cone overlap (28” bolt center-to-center) due to bolt spacing.
4. The TES allowable column bolt load of 83 kips is based on the material SA 193 B7 ultimate strength for a 2” diameter anchor and is calculated using a safety factor of 4.
5. The inner and outer columns have two clamping plates (i.e., one on each side) that are secured to the concrete with 2 concrete anchors each for a total of 4 anchors [7.7.11]
6. The TES calculation demonstrates that 128 kips (Table B-8) of upward outer column load on the two clamping plates results in 58 kips per bolt in each of 4 bolts due to the clamping plate offset moment.
7. The adjusted outer column load of 139 kips (Table B-8) results in a bolt load of 62.5 kips using the same methodology outlined in the Referenced TES Calculation.

8. The Referenced Drawing which is also marked as-built clearly shows in View B-B that the concrete anchors are embedded 2 ft +2"/-0". Adjusting for the full embedment depth and shear cone overlap using the referenced TES calculation methodology the allowable column bolt load is 72 kips.
9. Per the PUAAG and discussion in Section 2.11.2 all controlling load cases are Service Level A for the piping and supports.
10. TES weld allowable loads were calculated based on the Service Level A Code Allowable. Per Section 2.14, the Service Level A Allowable Stress Value is 0.30 S_U = 0.30 x 70 ksi = 21 ksi.
11. TES bending allowable stress values were calculated based on the Service Level A Code Allowable. Per Table NF-3312.1(b)-1 the Service Level A Allowable Stress Value is 0.75 S_Y = 29 ksi [7.5.2]. Where S_Y for A516 Gr 70 is 38 ksi [Section 2.13].
12. The TES reported bending stress in the clamping plate used the 83 kip per bolt maximum achievable load based on the material ultimate strength to load rate the plate.
13. The adjusted bending stress in the clamping plate used the outer column adjusted bolt load of 62.5 kips.

The download and upload results demonstrate the acceptability of the columns and column components as they meet ASME Code Section III, allowable stress values consistent with the MK I Program Event Combinations 18 and 25 for the JAF NPPP Primary (Metal) Containment [7.5.2].

Column to Shell Weld Analysis

The FitzPatrick Torus Saddle Analysis Calculation and PUAR listed the column to shell weld analysis provided in Table B-10 below based on 1/32nd Model FEA [7.4.3 Page 69 & 75 of 175, & 7.3.2 Para. 3.3.2].

Table B-10 - Column to Shell Weld Stress Results Based on TES 1/32nd Model FEA

Component	Event Combination	Type of Stress	Actual Stress	Allowable Stress	Reference
Inner Column to Shell Weld	16	Shear	16.42 k/in	24.13 k/in	[7.4.3 Page 69 of 175]
Outer Column to Shell Weld	16	Shear	16.96 k/in	24.13 k/in	[7.4.3 Page 75 of 175]

Table Notes:

1. The TES PUAR reported the Inner Column to Shell Weld Load as 15.82 k/in. The report did not include the 0.6 k/in drag load effect from the calculation.

The combined Drag Load of 0.6 k/in was conservatively included in the stress intensity reported by TES for the column web welds to account for drag load effects in column region for EC 16 [7.4.3 Page 69 &75 of 175]. The drag load stress intensities at the column to shell weld were based on the 0.0 ∆P LOCA Bubble, VH Support Columns and RG LOCA Bubble and later validated using the saddle to shell weld information also provided in TES Calculation 5321-23 and listed on Table B-11 below [7.4.3 Page 106 of 175].

Note that the referenced Saddle to Shell Weld used by TES to obtain the drag values was labeled "Worst Download" and results were compared to both the Accident 0.0 ∆P PS EC 16 and NO 1.7 ∆P PS EC 25 Allowable Service Level D values. Therefore, it is reasonable that all three loads were developed based on the controlling 0.0 ∆P Accident Condition loading. Thus, the Load Condition Adjustment Factors for 0.0 ∆P Accident Condition to NO Condition are 1.0 for LOCA Bubble and 1.05 for Vent Header Support Column PS Impact/ Drag [Section 5.1]. However, the 0.6 k/in load will still bound for the updated evaluation.

A second case from TES Calculation 5321-23 labeled "2nd Worst Down Load EC 25" also requires review [7.4.3 Page 109 of 175]. The results are presented in Table B-12 below. The LOCA Bubble for 0.0 ∆P have been taken from Table B-11, VH Support Column loads are identical to those reported for the TES Worst Case and are therefore at 0.0 ∆P Accident Condition and require the 1.05 Load Condition Adjustment Factor. SRV loads are unaffected by the PS change as given in Section 5.1. However, the LOCA loads on the RG for this case are at 1.7 ∆P and require the appropriate application of a submerged structure LOCA Bubble/Jet Load Condition Adjustment Factor of 2.1 [Section 5.1].

Table B-11 - EC 16 Drag Loads - Column to Shell Weld Location

Node #	Unit	LOCA Bubble (0.0 ∆P)	Vent Header Support Columns	LOCA Bubble on Ring Girder	Total Stress Intensities	Average Stress Intensity
495	k/in	0.468	0.219	0.006	0.693	0.517 x 1.05 = 0.542
521	k/in	0.104	0.231	0.006	0.341	

Table Notes:

1. Reference [7.4.3 Page 106 of 175]

For SRV and Drag Load effect, the column to shell weld loads for 0.0 ∆P EC 25 is listed in Table B-4. The SRV and drag load stress intensities at the column to shell weld are 0.72 k/in based on the 0.0 ∆P LOCA bubble, vent header support columns, SRV load on ring girder and LOCA+SRV on ring girder loads as provided in Table B-12 below [7.4.3 Page 106 of 175].

Table B-12 - EC 25 Drag Loads - Column to Shell Weld Location

Node	Unit	LOCA Bubble (0.0 ∆P)	Vent Header Support Columns	Ring Girder SRV Load	Ring Girder LOCA+SRV	Total	Average Stress Intensity
495	k/in	0.468	0.219 x 1.05 = 0.230	0.150	0.028*2.1=0.059	0.907	0.72
521	k/in	0.104	0.231 x 1.05 = 0.243	0.119	0.030*2.1=0.063	0.529	

Table Notes:

1. Reference [7.4.3 Page 109 of 175]

The 1/16th Model FEA bounding outer column to shell weld results are presented in Table B-13 for the 0.0 ΔP PS NO were calculated as 9.73 ksi vs. a 16.21 ksi allowable stress [7.3.4 Page 18 of 175]. The k/in results are converted to ksi based on the column web full penetration double (5/8 in) groove weld thickness of 1.25 in [7.4.3 Page 70 of 175]. Note that SRV and SSE are not included. As discussed in Section 2.15 based on the Saddle and Column load results the contribution of the combined SRV and SSE load is negligible.

Table B-13 - Results for Bounding Outer Column to Shell Weld Stress based on 1/16th Model FEA

Item	Unit	Outer Column Weld	Reference/Calculations
t_w, Web Weld Thickness	in	1.25	[7.4.3 Page 70 of 175]
EC 25 Drag Load at 0.0 ΔP	k/in	0.72	Table B-12
EC 25 Drag Stress at 0.0 ΔP	ksi	0.58	0.72 k/in x 1/1.25 in
1/16th FEA N + 0.0 ΔP PS	ksi	9.73	[7.3.4 Page 18 of 175]
EC 25	ksi	10.31	
S_U	ksi	70	Material is A516 Gr 70 [7.3.4 Attachment 3 Page 7 of 13]
SA, Level A Allowable	ksi	21	0.3 S_U x DLF [Section 2.14]

Torus Support Saddle and Weld Stress Evaluation

The controlling stress level in support saddles and saddle welds were listed in PUAR and FitzPatrick Torus Saddle Analysis Calculation as shown in Table B-14. Based on the evaluation above the controlling ↑ Upload is still from EC 21 with consideration of 0.0 ΔP NO. Therefore, the Saddle Clamping Plate and Saddle Anchor Bolt evaluation remains unchanged. However, based on the TES Calculation 5321-23 the saddle to shell weld was controlled by the EC 25 0.0 ΔP PS ↓ Download Phase [7.4.3 Page 104 of 175]. Therefore, the Altran scoping phase evaluation shall be incorporated [7.3.4 Attachment 3 Page 6 of 13]. The Outer Saddle Weld Area controls with an average weld load calculated at 4.34 kips/in. In addition, the drag loading on the weld shall be revised for 0.0 ΔP NO like the outer column to shell weld joint evaluation above. Table B-16 provides the necessary information.

Table B-14 - Saddle and Saddle to Shell Weld Stress Results Based on 1/32nd Model FEA

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual	Reference
Saddle Clamping Plate	21	Bending	51,700 lbf	75,000 lbf	N/A	[7.3.2 Para. 3.3.3]
	21	Bending	51,700 lbf	77,550 lbf	1.50	[7.4.3 Page 118 &125 of 175]
Saddle-to-Shell Weld Outside End	25	Shear	12.04 K/in	13.65 K/in	1.13	[7.3.2 Para. 3.3.3, 7.4.3 Page 105 &109 of 175]
Saddle Anchor Bolt	21	Tensile	51.7 K/bolt	264 K/bolt	5.1	[7.3.2 Para. 3.3.5, 7.4.3 Page 125 &127 of 175]

Table Notes:

1. Review of the Saddle Clamping Plate allowable calculation indicates that the allowable from the TES Calculation 5321-23 of 77,500 lbf was correct [7.4.3 Page 118 of 175] not the value of 75,000 lbf reported in the PUAR.
2. The actual Saddle to Shell Weld Stress reported was for Node #512 [7.4.3 Page 109 of 175].
3. The PUAR reported actual maximum load and maximum capacity of the saddle anchor bolts based on maximum bolt load and the concrete failure control mode including a safety factor of four (66*4=264 K/bolt) [7.3.2 Para. 3.3.5 & 7.4.3 Page 127 of 175].

The controlling stress level for saddle clamping plate and anchor bolts due to upload EC 21 will remain the same for 0.0 ∆P PS NO.

Based on a review of the Worst Case EC 16 and the 2nd Worst Case EC 25 Drag Loads from 5321-23, the 2nd Worst Case EC 25 controls for the Saddle to Shell Weld as the combination of Ring Girder SRV and LOCA + SRV Loads are significantly larger than the Ring Girder LOCA Bubble Loads [7.4.3 Pages 106 &109 of 175]. The loads are summarized below for Nodes 493 – 523 in k/in units:

Node	LOCA Bubble (0.0 ∆P)	Vent Header Support Columns	Ring Girder SRV Load	Ring Girder LOCA + SRV
493	0.000	0.000	0.000	0.000
494	0.000	0.000	0.000	0.000
495	0.468	0.219	0.150	0.028
496	1.295	0.114	0.352	0.015
497	2.119	0.211	0.531	0.027
498	2.810	0.230	0.662	0.029
499	3.340	0.212	0.798	0.027
500	3.755	0.284	0.918	0.036
501	4.128	0.668	0.992	0.085
502	5.022	1.069	1.161	0.206
503	5.964	2.890	1.301	0.369
504	6.268	3.736	1.356	0.478
505	6.596	3.883	1.431	0.497
506	7.036	3.362	1.551	0.430
507	7.054	2.619	1.569	0.335
508	6.817	2.256	1.540	0.289
509	6.817	2.615	1.574	0.335
510	6.680	3.351	1.551	0.429
511	6.055	3.856	1.430	0.493

Node	LOCA Bubble (0.0 ΔP)	Vent Header Support Columns	Ring Girder SRV Load	Ring Girder LOCA + SRV
512	5.668	3.779	1.393	0.484
513	5.252	2.847	1.324	0.364
514	4.189	1.609	1.159	0.206
515	3.379	0.664	1.001	0.085
516	2.952	0.288	0.922	0.037
517	2.512	0.216	0.806	0.028
518	1.998	0.233	0.670	0.030
519	1.363	0.212	0.529	0.027
520	0.666	0.108	0.339	0.014
521	0.104	0.231	0.119	0.030
522	0.000	0.000	0.000	0.000
523	0.000	0.000	0.000	0.000
Average	3.558	1.347	0.875	0.175
Load Condition Factor 0.0 ΔP NO	1	1.05	1	2.1
Average 0.0 ΔP NO	3.558	1.414	0.875	0.367

Based on the results of the table the Total Average 0.0 ΔP NO Drag Load is 6.214 k/in. Adding the 4.34 k/in from the Altran 1/16th Model for the controlling Outer Weld Joint side of the saddle to shell weld the total 0.0 ΔP PS weld joint load is 10.554 k/in. The weld geometry is a symmetric ½ in double-sided partial penetration groove weld [7.3.4 Attachment 3 Page 5 of 13]. Therefore, the final EC 25 stress value is also 10.6 ksi (i.e., weld area is 2 x ½ in thickness per 1 in length of weld = 1 in^2). The allowable stress value is 0.3 S_U = 0.3 x 70 = 21 ksi [Section 2.14].

C. TORUS RING GIRDER AND ASSOCIATED WELD EVALUATION FOR 0.0 ∆P NORMAL OPERATION

The controlling stress level in ring girder and ring girder welds were listed in PUAR and FitzPatrick Torus Saddle Analysis Calculation as shown in Table C-1.

Table C-1 - Ring Girder and Ring Girder to Shell Weld Stress Results TES FEA

Component	EC No.	Type of Stress	Actual	Allowable	Reference
Ring Girder Web	16	Membrane Stress Intensity	14.9 ksi	19.3 ksi	[7.3.2 Para. 5.4, 7.4.3 Page 4-5, 136 &137 of 175]
Ring Girder Flange	16	Membrane Stress Intensity	16.9 ksi	19.3 ksi	
Ring Girder-to-Shell Weld (Inner Column Region)	21	Shear Stress Intensity	7.64 k/in	8.53 k/in	
Ring Girder-to-Shell Weld (Outer Column Region)	21	Shear Stress Intensity	8.27 k/in	8.53 k/in	
Ring Girder-to-Shell Weld (Saddle Region)	21	Shear Stress Intensity	7.29 k/in	8.53 k/in	

Ring Girder Web and Flange

The controlling ring girder web and flange stress were calculated in Table C-2 [7.4.3 Page 135-137].

Table C-2 - Ring Girder Stress EC 16 Results – Teledyne Model

Stress Intensity, psi	**Ring Girder Web**	**Ring Girder Flange**	Reference
N	1569	1,573	[7.4.3 Page 135&137 of 175]
0.0 ΔP PS	6807	8,281	
(0.0 ΔP PS + N)	8,376	9,854	
LOCA Bubble (0.0 ΔP Accident)	4,576	4,571	[7.4.8 Page 31&32 of 175]
SRV Bubble on Ring Girder (Not effected by ΔP)	1,075	1,106	[7.4.8 Page 52]
LOCA Bubble on the SRV/ T-Quencher (0.0 ΔP Accident)	48	34	[7.4.8 Page 73]
SRV Bubble Drag on SRV System (Not effected by ΔP)	174	122	[7.4.8 Page 85]
Vent Header Impact	1,744	1,221	[7.4.8 Page 49] Note 100K per Column assumed
Total Stress Intensity	15,993	16,908	[7.4.3 Page 135&137]
Allowable Stress	1.5 S_{MC} = 28,950	S_{MC} = 19,300	[7.4.3 Page 135&137]

Table Notes:

1. The total stress intensity for ring girder web listed in the PUAR and summary table of FitzPatrick Torus Saddle Analysis Calculation 14.9 ksi did not include the stress from SRV bubble on the ring girder.

During the TES evaluation the ring girder loads for LOCA bubble, SRV bubble, SRV LOCA bubble, and Vent Header impact drag load were analyzed, the final VH column reaction loads were not available. The analyses were performed with an axial upward load of 100,000 lbs. on each of the VH columns (i.e., a total of 2 Vent Header support columns) [7.4.8 Page 48]. The axial load summary was later analyzed and updated for 0.0 ΔP NO [Attachment D]. The VH column axial loads were analyzed with the total maximum loads per event without consideration of time phasing. The maximum loads would not occur simultaneously [7.4.7 Page 3]. Thus, combined actual inner and outer column axial loads are 189,406 lbs and the 200,000 lbf total load used above is conservative [Attachment D –Table D-10].

Table C-3 - Ring Girder Stress EC 25 0.0 ΔP ↓ Download NO

Stress Intensity, psi	Load Condition Adjustment Factor	Ring Girder Web	Ring Girder Flange	Reference
N	1.0	1,569	1,573	[7.4.3 Page135 &137 of 175]
0.0 ΔP PS ↓ Download Phase NO	1.11	7,556	9,192	
(0.0 ΔP PS + N)		9,125	10,765	Note: Based on the Saddle and Column analysis SRV and SSE load contributions are negligible [Section 2.15].
LOCA Bubble (0.0 ΔP Accident)	1.0	4,576	4,571	[7.4.8 Page 31 & 32]
SRV Bubble on Ring Girder	1.0	1,075	1,106	[7.4.8 Page 52]
LOCA Bubble on the SRV/ T-Quencher	1.0	48	34	[7.4.8 Page 73]
SRV Bubble Drag on SRV System	1.0	174	122	[7.4.8 Page 85]
Vent Header Impact	1.05	1,831	1,282	[7.4.8 Page 49] Based on 100K per Column
SRV Thrust Load	1.0	856	600	
Total Stress Intensity EC 25		17,685	18,480	[7.4.3 Page 135&137 of 175]
Allowable Stress		1.5 S_{MC} = 33,000	S_{MC} = 22,000	[7.4.3 Page 135&137 of 175]
Allowable/Actual		1.87	1.19	

Ring Girder to Shell Weld

The newer refined 1/16th Model FEA from the Altran Draft Technical Report 13-0541-TR-001 was run with a DLF of 1.228 and both vent and non-vent bay PS pressure loads applied [7.3.4]. The results for the 0.0 ΔP PS and normal loads for the ring girder to shell weld were plotted and averaged as shown in Attachment 3 of the Altran Draft Technical Report 13-0541-TR-001 [7.3.4]. The average weld loads for the ring girder are summarized in Table C-4.

Table C-4 - Ring Girder to Shell Weld Load N+0.0 ∆P PS Results – 1/16th Model

Component	N+0.0 ∆P Load	Allowable
Inner Column Region	4.51 k/in	9.28 k/in
Outer Column Region	5.69 k/in	9.28 k/in
Bottom Half Ring Girder Region	(1.99+2.95)/2=2.47 k/in	9.28 k/in

Table Notes:

1. [7.3.4 Attachment 3].
2. Weld Allowable Stress Value 0.3 SU = 0.3 x 70 ksi = 21 ksi (Bounding Service Level A) per Section 2.14
3. Double-sided Fillet Weld Thickness – t weld = 5/16 in x .707 x 2 = 0.441 in
4. Weld Allowable 21 ksi x 0.441 in = 9.28 kips/in

In the Teledyne Model FEA, the ring girder to shell weld loads for EC 16 and EC 25 were listed for inner column region, outer column region and saddle region [7.4.3 Page 149,151, 167 & 170]. Table C-5 to Table C-6 providing a compilation of all the node forces at the regions for the two ECs.

The EC 18 and EC 25 weld loads for ring girder are then calculated as in Table C-7 and Table C-8.

Table C-5 - TES Ring Girder to Shell Weld Worst Download 0.0 ∆P (Accident Condition) EC 16 – 1/32nd Model Results

Column Location	Node	LOCA Bubble (0.0 ∆P) k/in	Vent Header Support Columns k/in
Inner Column Region	485	0.341	0.008
	486	0.289	0.013
	487	0.276	0.017
	488	0.873	0.019
	489	0.605	0.026
	490	0.843	0.028
	491	1.038	0.032
Saddle Region	492	1.212	0.037
	493	1.373	0.037
	494	1.466	0.024
	495	1.84	0.176
	496	2.464	0.114
	497	3.051	0.206
	498	3.528	0.218
	499	3.927	0.157
	500	4.201	0.208
	501	4.494	0.742

Column Location	Node	LOCA Bubble (0.0 ∆P) k/in	Vent Header Support Columns k/in
	502	5.173	1.690
	503	5.827	2.939
	504	6.08	3.770
	505	6.322	3.965
	506	6.563	3.473
	507	6.558	2.693
	508	6.398	2.285
	509	6.321	2.695
	510	6.178	3.472
	511	5.731	3.948
	512	5.38	3.820
	513	5.012	2.909
	514	4.228	1.699
	515	3.574	0.741
	516	3.199	0.203
	517	2.853	0.151
	518	2.422	0.215
	519	1.946	0.202
	520	1.415	0.110
	521	0.921	0.183
	522	0.823	0.030
	523	0.722	0.042
	524	0.604	0.040
Outer Column Region	525	0.499	0.035
	526	0.388	0.033
	527	0.260	0.032
	528	0.489	0.034
	529	0.190	0.021
	530	0.286	0.012
	531	0.272	0.007
Inner Column Region	Average	0.609	0.020
Outer Column Region	Average	0.341	0.025
All Region	Average	**2.733**	**0.926**

Table Notes:

1. Reference [7.4.3 Page 149 & 167]

Table C-6 - TES Ring Girder to Shell Weld Download 1.7 ΔP (NO) EC 25 – 1/32nd Model Results

Column Location	Node	LOCA Bubble (1.7 ΔP) k/in	Vent Header Support Columns k/in	SRV Bubble k/in	Ring Girder LOCA +SRV k/in
Inner Column Region	485	0.16	0.008	0.037	0
	486	0.136	0.013	0.143	0
	487	0.13	0.017	0.226	0
	488	0.41	0.019	0.263	0
	489	0.284	0.026	0.243	0
	490	0.396	0.028	0.327	0
	491	0.488	0.032	0.379	0
Saddle Region	492	0.569	0.037	0.417	0.0047
	493	0.645	0.037	0.450	0.0047
	494	0.689	0.024	0.467	0.0031
	495	0.864	0.176	0.544	0.0225
	496	1.158	0.114	0.686	0.0146
	497	1.433	0.206	0.785	0.0263
	498	1.658	0.218	0.866	0.0278
	499	1.845	0.157	0.958	0.0200
	500	1.974	0.208	1.028	0.0266
	501	2.111	0.742	1.077	0.0949
	502	2.430	1.690	1.190	0.216
	503	2.738	2.939	1.273	0.376
	504	2.857	3.770	1.313	0.483
	505	2.970	3.965	1.369	0.507
	506	3.084	3.473	1.440	0.444
	507	3.081	2.693	1.454	0.344
	508	3.006	2.285	1.441	0.292
	509	2.970	2.695	1.453	0.345
	510	2.903	3.472	1.434	0.444
	511	2.693	3.948	1.357	0.505
	512	2.528	3.820	1.324	0.489
	513	2.355	2.909	1.275	0.372
	514	1.986	1.699	1.171	0.217
	515	1.679	0.741	1.064	0.095
	516	1.503	0.203	1.010	0.026
	517	1.340	0.151	0.940	0.019
	518	1.138	0.215	0.844	0.028
	519	0.914	0.202	0.760	0.026
	520	0.665	0.110	0.655	0.014
	521	0.433	0.183	0.513	0.023
	522	0.387	0.030	0.443	0.0038
	523	0.339	0.042	0.421	0.0054
	524	0.284	0.040	0.377	0.0051
	525	0.234	0.035	0.326	0

Column Location	Node	LOCA Bubble (1.7 ΔP) k/in	Vent Header Support Columns k/in	SRV Bubble k/in	Ring Girder LOCA +SRV k/in
Outer Column Region	526	0.182	0.033	0.262	0
	527	0.122	0.032	0.178	0
	528	0.230	0.034	0.273	0
	529	0.089	0.021	0.138	0
	530	0.134	0.012	0.099	0
	531	0.128	0.007	0.056	0
Inner Column Region	Average	0.286	0.020	0.231	0
Outer Column Region	Average	0.160	0.025	0.190	0
All Region	Average	1.284	0.926	0.739	.118

Table Notes:

1. Reference: [7.4.3 Page 151 & 170 of 175]

Table C-7 - Ring Girder to Shell Average Weld Load 0.0 ΔP (NO) EC 18 – 1/16th Model Results

Ring Girder Weld Location	1/16th Model (N+0.0 ΔP PS NO) k/in	LOCA Bubble (0.0 ΔP) k/in	Vent Header Support Columns (0.0 ΔP) k/in	EC 18 k/in	Allowable k/in	Ratio
Inner Column Region	4.51	0.609 x 1.0= 0.61	0.020 x 1.05 = 0.02	5.14	9.28	1.81
Outer Column Region	5.69	0.341 x 1.0 = 0.34	0.025 x 1.05 = 0.03	6.06	9.28	1.53
Bottom Half Ring Girder Region	2.47	2.733 x 1.0 = 2.73	0.926 x 1.05 = 0.97	6.17	9.28	1.50

Table Notes:

1. Like the Saddle and Column Weld Joints the 0.0 ΔP PS ↑ Upload Vent Header Column Load is adjusted per Table 13. The LOCA Bubble factor is 1.0.
2. Weld Allowable Stress Value 0.3 S_U = 0.3 x 70 ksi = 21 ksi (Bounding Service Level A) per Section 2.14
3. Double-sided Fillet Weld Thickness – t_{weld} = 5/16 in x .707 x 2 = 0.441 in

4. Weld Allowable 21 ksi x 0.441 in = 9.28 kips/in
5. Per Section 2.15, SSE loads are negligible

Table C-8 - Ring Girder to Shell Average Weld Load 0.0 ΔP (NO) EC 25 – 1/16th Model Results

Ring Girder Location	1/16th Model (N+0.0 ΔP PS) k/in	LOCA Bubble (0.0 ΔP) k/in	Vent Header Support Columns k/in	SRV Bubble k/in	Ring Girder LOCA+ SRV	EC 25 k/in	Allowable k/in	Ratio
Inner Column Region	4.51	0.61	0.02	0.23	0.000	5.44	13.89	2.55
Outer Column Region	5.69	0.34	0.03	0.19	0.000	6.29	13.89	2.21
Bottom Half Ring Girder Region	2.47	2.73	0.97	0.74	0.118 x 2.1 = 0.25	7.36	13.89	1.89

Table Notes:

1. Weld Allowable Stress Value 1.5 x 0.3 S_U = 0.45 x 70 ksi = 31.5 ksi per Section 2.14
2. Double-sided Fillet Weld Thickness – t_{weld} = 5/16 in x .707 x 2 = 0.441 in
3. Weld Allowable 31.5 ksi x 0.441 in = 13.89 kips/in
4. Per Section 2.15, SRV and SSE loads are negligible

D. VENT HEADER SYSTEM STRESS EVALUATION

Vent Header/ Downcomer Intersection

The controlling stress in VH/DC intersection at 1.7 ΔP Normal Operation was listed in PUAR [7.3.2 Para. 4.4.1] and is reflected in the results shown in Table D-1.

Table D-1 - Controlling Stress in Vent Header/ Downcomer Intersection – TES

Component	EC	Type of Stress	Actual	Allowable	Ratio	Reference
VH/ DC Intersection	15 (IBA CO)	Combined Maximum Stress	35,303 psi	37,635 psi	1.07	[7.3.2 Para. 4.4.1] [7.4.13 Page 13 of 13]

The reported VH/ DC Intersection stress results are for P_M+P_B stress intensity. For 0.0 ΔP NO, loads require adjustment using the Section 5.1 factors from 1.7 ΔP to 0.0 ΔP NO.

Table D-2 - Controlling Stress in VH/DC Intersection - 0.0 ΔP NO

	Load Combination	Stress 1.7 ΔP NO psi	Factor	Stress 0.0 ΔP NO psi	Reference
A	Pool Swell (impact & drag)	11,394	1.29	14,698	[7.4.13 Page 7 of 13]
B	Chugging	17,599	1.00	17,599	[7.4.13 Page 13 of 13]
C	SRV	16,547	1.00	16,547	[7.4.13 Page 13 of 13]
D	Thrust + SSE + Deadweight	629	1.17	736	[7.4.13 Page 8 &13 of 13]
E	Pressure	528	1.0	528	[7.4.13 Page 13 of 13]
F	S_{MC} for SA 516 Gr.70			22,000	[Section 2.13
G	S_y for SA 516 Gr.70			38,000	[Section 2.13
H	EC 15 = B+C+D+E			35,410	
I	EC 18 = A+D+E			15,962	SSE is used to bound EC 18
J	EC 25 = A+C+D+E			32,509	
K	Level B Allowable Stress Value = 1.5 x 1.3 x S_{mc}			42,900	Section 2.11.1 & Table Note 7 below
L	Level C Allowable Stress Value = 1.5 * S_y			57,000	Section 2.11.1
	Allowable/Actual - EC 15 =K/H			1.21	Service Level B is used to bound EC 14
	Allowable/Actual - EC 18 =K/I			2.69	Service Level B is used to bound EC 18
	Allowable/Actual - EC 25 =L/J			1.75	

Table Notes:

1. The PS loads are impact and drag loads. The Load Adjustment Factor is given in Section 5.1 as 1.29.
2. Downcomer pressure for 1.7 ∆P was listed at 16 psi [7.4.13 Page 8 of 13]. The downcomer pressure is variable P3 (Table F4.2-1) and it occurs at approximately 1.5 sec at the end of the event based on Figure F 4.2-10 from the PULD [7.2.4].
3. Downcomer pressure for 0.0 ∆P was not listed in the referenced calculation. The corresponding downcomer pressure that occurs at approximately 1.5 sec into the event based on Figure F 4.2-10 from the PULD is 16 psi.
4. EQ values listed are for the SSE Case based on the 0.15g value [Section 2.10.14].
5. The peak DBA Vent System Thrust loads are calculated as those which occur due to vent system clearing [7.4.13 Page 8 of 13].
6. Conservatively, the combination of Thrust + SSE + Deadweight was factored with the largest factor of the three loads 1.17 [Section 5.1].
7. Per the PUAAG Table 5-2 Note 4 the S_{MC} used to calculate the allowable stress values at the VH/DC intersection (i.e., penetration) may be increased by a factor of 1.3.

EC15 is still the controlling stress in the downcomer intersection. The calculated combined maximum stress intensity values meet Code Allowable Stress Intensity requirements for EC 15, EC 18 and EC 25. The VH/DC Intersection is acceptable for service at 0.0 ∆P NO.

Vent Header/ Vent Pipe Intersection

The VH/ VP minimum margin of safety (MS) from TES Calculation 2386-8 was reported for the VH at the Intersection with the VP [7.4.9 Page 1 of 20].

Components reviewed in the calculation include:

- VH at the VP intersection: MS = 0.08 Ratio = 1.08
- VP at the intersection with the VH MS = 1.92 Ratio = 2.92 (The VP/Drywell Intersection Results are reported below)
- VH at the VH mitre joint MS = 0.529 Ratio = 1.529 (Results reported below)
- Downcomers MS = 2.20 Ratio = 3.20 (The VH/DC Intersection Results are reported above)
- Vent Pipe MS = 1.18 Ratio = 2.18 (The VP/Drywell Intersection Results are reported below)

Therefore, this paragraph of the Attachment will focus on the VH/ VP intersection as listed in PUAR for 1.7 ∆P NO. The TES VH/VP results are provided in Table D-3 below.

Table D-3 - Controlling Stress in VH/VP Intersection – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
VH/ VP Intersection	25 (1.7 ∆P PS)	Combined Maximum Stress	26,748 psi	28,950 psi	[7.3.2 Para. 4.4.2] [7.4.9 Page 12 of 20]

The maximum combined stress based on PS load was located at Node 1 Element 10 [7.4.9 Page 10 of 20]. The loading condition was listed below in Table D-4.

Table D-4 - VH/VP Intersection Loads at Node 1 Element 10 - 1.7 ΔP NO

Load	X1	X2	X3	M1	M2	M3
Dead Weight	-3,700	-3,580	-1,533	54,195	50,731	-156,730
Seismic (SSE)	±7,244	±1,760	±4,564	±36,828	±182,166	±67,243
Thrust	-42,937	-9,969	4,406	-194,587	-134,221	-297,365
Pool Swell	-79,554	-20,108	-16,391	1,423,444	1,007,248	-1,368,028
Chugging	-64,024	13,409	34,163	-2,250,440	-1,589,740	-380,501

Table Notes:

1. Loads units are lbs. for X and in-lbs. for M.
2. Reference [7.4.9 Page 9 and 10 of 20]

For 0.0 ΔP Normal Operation, the Load Condition Adjustment Factors from 1.7 ΔP NO to 0.0 ΔP Normal Operation from Section 5.1 are applied as given in Table D-5.

Table D-5 - VH/VP Intersection Loads at Node 1 Element 10 - 0.0 ΔP NO

Load	Factor	X1	X2	X3	M1	M2	M3
Dead Weight	1.00	-3,700	-3,580	-1,533	54,195	50,731	-156,730
Seismic (OBE)	0.54	±3,916	±951	±2,467	±19,907	±98,468	±36,348
Seismic (SSE)	1.00	±7,244	±1,760	±4,564	±36,828	±182,166	±67,243
Thrust	1.17	-50,236	-11,664	5,155	-227,667	-157,039	-347,917
Pool Swell Impact & Drag	1.29	-102,625	-25,939	-21,144	1,836,243	1,299,350	-1,764,756
Chugging	1.00	-64,024	13,409	34,163	-2,250,440	-1,589,740	-380,501

Table Notes:

1. Loads unit are lbs for X and in-lbs for M.
2. Reference [7.4.9 Page 10 of 20]
3. Load Condition Adjustment Factors are given in Section 5.1
4. Earthquake Adjustment for OBE to SSE is given in Section 2.10.14

The above loads (dead weight, seismic, thrust and PS) will be combined as follows:

$$EC\ 18\ \&\ 25\ DW \pm \sqrt{(TH + PS)^2 \pm EQ^2}$$

EQ is combined with the sign of the algebraic sum for TH+PS for the 0.0 ΔP NO ECs 18 & 25. Results are given in Table D-6.

Table D-6 - VH/VP Intersection Loads at Node 1 Element 10– PS Max and Min Loads

EC	X1	X2	X3	M1	M2	M3
Max – EC 25	3,544	-1,820	5,352	1,890,807	1,362,788	-89,487
Min – EC 25	-156,732	-41,224	-23,164	-176,431	-189,780	-2,270,473
Max – EC 18	216	-2,629	4,182	1,890,546	1,353,807	-120,382
Min – EC 18	-156,611	-41,195	-22,821	-174,340	-134,626	-2,269,716

Table Notes:

1. Loads unit are lbs for X and in-lbs for M.
2. The component is above water, so there is no SRV load
3. EC 25: Dead Weight, Seismic (SSE), Thrust, Pool Swell
4. EC 18: Dead Weight, Seismic (OBE), Thrust, Pool Swell.

The TES 2386-8 calculation provides the following to obtain the principal stress results [7.4.9 Page 10 of 20]. The principal stress can be calculated by the following equation using the absolute value results from Table D-6:

$$\sigma = [(\frac{X_1}{A} + \frac{m_r}{S})^2 + 4 * \left(\frac{m_1}{2S} + \frac{X_r}{A/2}\right)^2]^{1/2}$$

where $m_r = ({m_2}^2 + {m_3}^2)^{1/2}$, $X_r = ({X_2}^2 + {X_3}^2)^{1/2}$, A is the area and S is the section modulus. The maximum and minimum principal stresses were then calculated as:

$\sigma_{max} = 4{,}099 psi$ and $\sigma_{min} = 8{,}346 psi$ For EC25

$\sigma_{max} = 4{,}000 psi$ and $\sigma_{min} = 8{,}327 psi$ For EC18

Then the load at 0.0 ΔP NO is evaluated as in the Table D-7. Note that the above equation provides P_L+P_B results for the VH/VP Intersection. TES compared these results to 1.0 S_{MC}. Per the Code P_L+P_B is compared to 1.5 S_{MC} [Section 2.11.1]. In addition, these results are at an intersection which is a discontinuity that creates the local stress region.

Table D-7 - VH/VP Intersection EC18 and EC 25 Loads at 0.0 ΔP Normal Operation

Label	Item	Unit	Value	Reference
A	Max (P_L+P_B) - EC 25	psi	4099	
B	Min (P_L+P_B) - EC 25	psi	8346	
C	Max (P_L+P_B) - EC 18	psi	4000	
D	Min (P_L+P_B) - EC 18	psi	8327	
E	P_L+P_B SIF	-	2.75	[7.4.9 Page 9 of 20]
F	Pressure SIF	-	3.5	[7.4.9 Page 9 of 20]
G	Pressure	psi	1139	[7.4.9 Page 11 of 20]
H	Primary Stress EC25	psi	26,938	=A*E+F*G
I	Primary Stress EC18	psi	26,885	=C*E+F*G
J	S_{mc} for SA 516, Gr.70	psi	22,000	[7.4.9 Page 5 of 20], Table 11, & 7.5.4, Table 1A]
K	Level B allowable 1.5*S_{mc}	psi	33,000	[7.5.2, Table NE-3221-1]
L	S_y for SA 516, Gr.70	psi	38,000	[7.5.4, Table 1A]
M	Level C Allowable 1.5*S_y	psi	57,000	[7.5.2, Table NE-3221-1]
	Allowable/Actual - EC 18		1.23	=K/I
	Allowable/Actual - EC 25		2.12	=M/H

The VH/VP intersection P_L+P_B Local Stress Intensity satisfies Code requirements for 0.0 ΔP NO.

Vent Header Support Columns and Attachments

The controlling stress values in VH support columns and clevis joints at 1.7 ΔP NO were listed in the PUAR and TES VH support calculation as provided in Table D-8.

Table D-8 - Controlling Stress Reported for VH Support Components - TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Vent Header Support Columns	25	Tension and Bending	0.654	1	[7.3.2 Para. 4.4.3, [7.4.7 Page 20 of 27]
Clevis Joints	25	Bearing	26,175 psi	27,000 psi	[7.3.2 Para. 4.4.3, 7.4.7 Page 24 of 27]

The total axial loads for the VH support columns were calculated as provided in Table D-9.

Table D-9 - Summary of VH Support Axial Loads at 1.7 ∆P NO - TES

Label	Event	Inner Col. Load, lbs	Outer Col. Load, lbs
A	Pool Swell Impact & Drag on the Vent Header, 1.7 ∆P NO	44,462	57,454
B	Vent System Thrust, 1.7 ∆P NO	24,316	22,533
C	Pool Swell Impact & Drag on the Deflector, 0.0 ∆P Accident	26,990	26,990
D	Seismic	±4,139	±4,456
E	Deadweight	-26,431	-27,279
Bounding EC 18 & 25	Total Tension: 69,426+79,791=149,217lbs		
	$\sqrt{(A+B+C)^2+D^2}-E=$	69,426	79,791
	Total Compression: 30,570+31,735=62,305lbs		
	D+E=	30,570	31,735

Table Notes:

1. Reference: [7.4.7 Page 6 of 27]
2. SRV contributes to the bending stress in the column not the axial stress

Revision 1 to Reference 7.4.7 indicates that Pool Swell Impact & Drag and Vent System Thrust were evaluated for 1.7 ∆P NO.

Attachment A provides a copy of the Rev.0 calculation for the Vent Header Support Analysis. It indicates that the same Pool Swell Impact & Drag and Vent System Thrust loads used are for 0.0 ∆P Accident Condition [7.4.7 Page A4 of A7].

However, careful review of the listed computer run sequences No. AAMNOVP and TPL00GA indicate that both cases were run for 1.7 ∆P NO [7.4.7 Page A7 of A7 and 7.4.9 Page 9 of 20].

To calculate the current 0.0 ∆P axial loads, factors from 1.7 ∆P NO to 0.0 ∆P NO were applied as shown in below table.

Table D-10 - Summary of Vent Header Supports Axial Loads - 0.0 ∆P NO

Label	Event	Factor [Section 5.1]	Inner Col. Load, lbs	Outer Col. Load, lbs
A	Pool Swell Impact & Drag on the Vent Header, ∆P=0	1.29	57,356	74,116
B	Vent System Thrust, ∆P=0	1.17	28,450	26,364
C	Pool Swell Impact & Drag on the Deflector, ∆P=0	1.05	28,340	28,340
D	Seismic	1	±4,139	±4,456
E	Deadweight	1	-26,431	-27,279
Bounding for EC 18 & 25	Total Tension: 87,789+101,617=189,406 lbs			
	$\sqrt{(A+B+C)^2+D^2}-E=$		87,789	101,617
	Total Compression: 30,570+31,735=62,305lbs			
	D+E=		30,570	31,735

The VH column axial loads were analyzed for the total combined maximum regardless of load timing (i.e., the loads were not time phased prior to combination). The maximum loads would not occur simultaneously [7.4.7 Page 3 of 27]. Thus, the total tension loads calculated is conservative.

Based on the updated vent header axial load at 0.0 ∆P NO, the vent header support column load was reevaluated for EC 25 as provided in the following table, Table D-11.

Table D-11 - Vent Header Column Evaluation - Tension and Bending EC 25 - 0.0 ΔP NO

	Item	Unit	Value	Reference
A	Column Area	$inch^2$	8.4	[7.4.7 Page 8 of 27]
B	Outer Column Total Tension Load	lbs	101,617	Table D-10
C	LOCA Jet (2837)/Bubble (1804) 0.0 ΔP	psi	2,837	Use Bounding Value [7.4.7 Page 19 of 27]
D	SRV DRAG	psi	926	[7.4.7 Page 19 of 27]
E	Seismic	psi	194	[7.4.7 Page 19 of 27]
	Yield Strength (Column Material A333 Gr.1)	psi	30,000	Section 2.13
	Tension			
F	B/A=	psi	12,097	Tension Load/Area
G	Allowable = 0.6 S_Y	psi	18,000	[7.5.2, NF-3322.1]
	Bending			
H	$\sqrt{C^2+D^2+E^2}$=	psi	2,991	
I	Allowable = 0.66 S_Y	psi	19,800	[7.5.2, NF-3322.1]
	Tension and Bending Interaction			
	F/G+H/I=	-	0.82	
	Allowable	-	1	
	Ratio - Allowable/Actual	-	1.21	

EC 18 & EC 25 PS Interaction Ratios are bounded using the allowable stress values for Service Level A. [7.5.2, NF-3382.2]. Thus, the vent header column tension and bending loads satisfied Code requirements for continued operation at 0.0 ΔP NO.

The clevis joints bearing force evaluation was updated using the vent header axial load at 0.0 ΔP NO in Table D-12.

It is noted that the TES calculation 2386-2 conservatively used an allowable stress value for bearing stress of 1.0 S_Y. However, the ASME Code allowable stress value for bearing stress on pins is discussed in Para. NF-3223.1. The required allowable stress value is 1.5 S_Y if credit is not given to the bearing area within one pin diameter from the plate edge [7.5.2, NF-3223.1]. Pin bearing area beyond the plate edge is not considered. Therefore, the allowable stress value is 1.5 S_Y.

Table D-12 - Vent Header Pin Evaluation for Bearing EC 25 - 0.0 ΔP NO

	Item	Unit	Value	Reference
A	Pin Diameter	in	2.75	[7.4.7 Page 21 of 27]
B	Pin Thickness	in	1.0	[7.4.7 Page 21 of 27]
	Pin Bearing Area			
C	A*B=	in^2	2.75	Note: Upper Clevis Plate is 1" Thick [7.4.7 Page A3 of 7]
D	Yield Strength, Pin Material - A276 TP 304	psi	30,000	[7.4.7 Page A5 of 7]
	Outer Column Total Tension Load	lbs	101,617	Table D-10
	Outer Column Bending Load	lbs	2991	
E	Outer Column Total	lbs	101661	$\sqrt{101617^2 + 2991^2}$
	Bearing			
	E/C=	psi	36,968	
	Allowable			
	1.5*D	psi	45,000	[7.5.2, NF-3223.1]
	Allowable/Actual	-	1.22	

The remaining components are reviewed in Table D- 13 since the Allowable Stress Value for the Pin Bearing Stress was increased and the associated Ratio improved.

Table D- 13 - Review of Remaining VH Column Components

VH Column Component	Stress Type	Stress psi	Allowable Stress psi	Ratio	Adjusted Ratio
Clevis Plate	Shear	6649	13840	2.08	1.64
Clevis Plate	Tension	10132	15570	1.54	1.21
Pin	Shear	6716	12000	1.79	1.41
VH Ring	Shear	9974	13840	1.39	1.39
Column Lugs	Weld	6654	18000	2.71.	2.13

Table Notes:

1. Additional stress results reported by TES Calculation 2386-2 R1 [7.4.7].
2. Stress ratio was adjusted by old/new column load.
   a. Old: 79792 lbs Page 21 of 27

b. New: $\sqrt{101617^2 + 2991^2} = 101661\ lbs$

c. Ratio = 101661/79792 = 1.27

The VH Column pin bearing load satisfies the Code requirement for 0.0 ∆P NO. The remaining components; Clevis Pin, VH Ring and Column Lugs have been reviewed and they also meet Code requirement for continued service at 0.0 ∆P NO.

Vent Header/ Downcomer Tie-Bars and Attachments

The controlling stress in downcomer tie-bars and attachment at 1.7 ∆P was listed in PUAR and Teledyne vent header/ downcomer tie-bar analysis as shown in Table D-14 [7.3.2 Para. 4.4.4 &7.4.14 Page 9 of 11]. The major load is associated with pool swell impact on the VH/DC crotch region which produces tensile loads in the tie bar [7.3.2 Para. 4.4.4].

Table D-14 - Controlling Stress in Vent Header Downcomer Tie-Bars – Teledyne

Component	EC	Stress Type	Actual	Allowable	Reference
Tie Bar Clamp	25	Bending	10,614 psi	22,240 psi	[7.3.2 Para. 4.4.4] [7.4.14 Page 9 of 11]

The PUAR stated that 0.0 ∆P PS loads and Service Level A Allowable Stress Values were conservatively used in the analysis. The maximum loads in the tie-bars were found in elements 300-305 for dead weight, seismic and thrust loads using beam model while the pool swell maximum loads were taken from elements 1185 and 1186 from finite element model computer run # SJH00IZ [7.4.14 Page 5 and 8 of 11]. The computer run # SJH00IZ was indicated as operation 1.7 ∆P in VH/DC intersection analysis [7.4.13 Page 9 of 13]. Therefore, all the loads are treated as 1.7 ∆P NO then will be factored to 0.0 ∆P NO loads.

Table D-15 - Maximum Loads on the Tie-Bar Clamp

Load, lbs	Fx_1' (1.7 ∆P)	Factor	Fx_1'(0.0 ∆P)
Deadweight	-87	1	-87
Seismic	±14	1	±14
Thrust	-1051	1.17	-1,230
Pool Swell Impact & Drag	571	1.29	736
Total	1723		2067

Table Notes:

1. Tension is positive/ compression is negative.
2. Absolute values were added for conservatism.
3. Seismic is SSE.

4. References: 7.4.14 Page 8 of 11, & Section 5.1.

The clamp can be considered as a curved beam and calculated as [7.4.14 Page 9 of 11]:

$$\sigma_b = 6.16 * 2067psi \ = 12{,}734psi$$

The level B bending stress limits for SA 516, Gr.70 @ 200F material is [7.4.14 Page 9 of 11]:

$$0.66 * Sy = 0.66 * 33.7\ ksi = 22.24\ ksi.$$

The results for the controlling stress in vent header Tie-Bars are updated in Table D-16.

Table D-16 - Controlling Stress in VH/ Downcomer Tie-Bars – 0.0 ∆P NO

Component	Load Case Number	Type of Stress	Actual	Allowable	Allowable/Actual
Tie Bar Clamp	25	Bending	12,734 psi	22,240 psi	1.75

The ratio of allowable to actual stress is 1.75. Therefore, the DC tie-bar load meets Code requirements and is acceptable for continued service at 0.0 ∆P NO. The next most controlling item listed in TES Calculation 2386-2 is the insert weld to the tie-bar pipe. The weld allowable load is 3182 k/in and the calculated load is 1051 k/in. If we adjust the allowable/ actual ratio by the maximum load condition adjustment factor of 1.29 (Table D-15) used herein the ratio 2.35. Considerable margin exists in the remaining DC tie-bar components.

<u>Vent Header Deflector and Attachments</u>

The controlling stress in VH deflector and attachment was listed in PUAR and Teledyne's FitzPatrick pool swell loads on vent header deflector & its supports analysis as shown in Table D-17 [7.3.2 Para. 4.4.5 &7.4.15].

Table D-17 - Controlling Stress in Vent Header Deflector and Attachments – TES

Component	Load Case Number	Type of Stress	Actual	Allowable	Reference
Deflector – Center of the Long Span	25	Bending	6,236 psi	16,500 psi	[7.3.2 Para. 4.4.5 & 7.4.15 Page 7 of 27]
Attachments – Fillet Weld	25	Shear	10,662 psi	18,000 psi	[7.3.2 Para. 4.4.5]

The vent header deflector was evaluated in Calculation 2386-5. It is treated as a simply supported beam with two supports and cantilevered overhang on both ends. A uniformly distributed load of 3600 lbs/ft was applied based on early 0.0 ∆P PS test results with a multiplier of 3 to assure that the load bounded the final testing [7.4.15 Page 3 of 27]. The final test results were incorporated in the calculation as addenda. No changes were made to the evaluation due to the conservative multiplier of 3.0. The tests were run with the knowledge that the results were to be used to design the deflector for JAF therefore no increase is required for limited testing. Imperia could not reproduce the Shear Stress in the attachment fillet welds. The calculation is a design calculation, so the weld evaluation was generally performed to determine fillet weld size. It is apparent that the welds and bending in the deflector were evaluated to Service Level A allowable stress values.

Table D-18 - Weld Stress in Vent Header Deflector Components

Weld Location	Fillet Weld Size	Fillet Weld Shear Stress psi	Level D Allowable Stress Value [0.51S_U = 0.51(70)] [Section 2.14]	Reference [7.4.15]
Pipe Support Lugs (5" long)	3/8" All Around	63722 lbs x 1 / 0.707 x 3/8" x 2 x 5" = 24,034	35,700 psi	Page 15
Deflector/ VH Weld (40" long)	3/8" All Around	3939 lbs/in x 1/0.707 x 3/8" x 2" = 75429	35,700 psi	Page 16
Ring Clevis Weld (40-1/2" long)	3/8" Double Sided	13110	35,700 psi	Page 25

PUAR Table 5-1 defined the stress allowable for the vent header as Level D [7.3.2, Table 5-1 Class MC Components and Internal Structures]. For SA-106 GR B material, S_U = 60 ksi [Table 11]. The allowable stress value for $P_m + P_B$ = 1.5 x 0.70 S_U = 63,000 psi [Section 2.11.1].

The weld shear stress Service Level D Allowable Stress Value is 0.51 S_u (0.51*70=35.7 ksi) noting that for the double sided fillet welds the base metal will not control [Section 2.14].

The results for the controlling stress in vent header deflector and attachment welds are updated in Table D-19.

Table D-19 - Controlling Stress in VH Deflector and Attachment – 0.0 ∆P NO

Component	EC (0.0 ∆P)	Type of Stress	Actual	Allowable	Allowable/ Actual
Deflector – Center of the Long Span	25	Membrane + Bending	6,236 psi	63,000 psi	10.10
Attachments – Fillet Weld	25	Shear	24034 psi	35700 psi	1.49

Table Notes:

1. The Vent Header Jet Deflector was conservatively analyzed with a factor of 3.0 on the tested load to assure Code compliance. Therefore, the minimum ratio of 1.49 is greater than listed.

Vent Header Main Vent/ Drywell Intersection

The major load on the drywell penetration were listed in PUAR and Teledyne vent header main vent/drywell intersection analysis as shown in Table D-20 [7.3.2 Para. 4.4.6 &7.4.16 Page 17 of 18].

Table D-20 - Controlling Stress in VH Main Vent/ Drywell Intersection – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Drywell Penetration	21	Primary and Secondary	23,664 psi	69,900 psi	[7.3.2 Para. 4.4.6] [7.4.16 Page 17 of 18]
Vent System	21	Primary and Secondary	17,724 psi	69,900 psi	[7.3.2 Para. 4.4.6]
Vent-to-drywell intersection	21	Primary and Secondary	41,388 psi	69,900 psi	[7.3.2 Para. 4.4.6]

The stress results reported by TES in the PUAR are all Primary + Secondary Stresses and are unaffected by changes to the PS loading per PUAAG Table 5-2 Note 3 as discussed in Section 2.3.

The drywell shell at the vent pipe penetration was analyzed using the NO 1.7 ΔP results in TES Calculation 2386-4 [7.4.16]. The calculation determined that the bounding case was EC 19 using 1.7 ΔP TH + PS. The 0.0 ΔP PS load was noted to be of lower magnitude (i.e., the 1.7 ΔP PS was “more severe” [7.4.16 Page 7 of 18]. The primary membrane stress for EC 19 (PS + N + SSE) was calculated as 9,375 psi based on the bounding 1.7 ΔP PS load [7.4.16 Page 16 of 18]. Thus the 0.0 ΔP PS impact & drag load for EC 18 (PS + N + OBE) NO can then be conservatively calculated by 9,375 x 1.29 = 12,094 psi. The Service Level B primary stress allowable value for the A 516 Gr. 70 material is 1.5 X S_{mc} = 1.5 * 22 = 33 ksi [7.4.16 Page 16 of 18 & Sections 2.11.1 & 2.13].

The results for the controlling stress in vent header main vent/drywell intersection are then updated in Table D-21.

Table D-21 - Controlling Stress in VH Main Vent/ Drywell Intersection – 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Drywell Penetration	19	Membrane + Bending	12,094 psi	33,000 psi	2.73

Vent Header, Main Vent and Downcomer – Free Shell Stresses

TES established that minimum safety margins would be controlled by local shell stresses such as intersections [7.3.2 Para. 4.4.7]. No further work needs to be done for free shell stress in the structures.

Vent Header/ Mitre Joint

The controlling stress in vent header mitre joint were listed in PUAR and Teledyne's FitzPatrick pool swell loads on vent header vent pipe/ vent header intersection analysis as shown in Table D-22 [7.3.2 Para. 4.4.5 & 7.4.9].

Table D-22 - Controlling Stress at VH Mitre Joint – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Vent Header– Mitre Joint	25	Combined Maximum Stress	18,935 psi	28,950 psi	[7.3.2 Para. 4.4.8] [7.4.9 Page 17 of 20]

The maximum combined stress based on pool swell load was located at Node 16 Element 14 [7.4.9 Page 17 of 20]. The loading condition was listed in below table (Table D-23):

Table D-23 - VH Mitre Joint Loads at Node 16 Element 14 - 1.7 ∆P NO

Load	X1	X2	X3	M1	M2	M3
Dead Weight	-4,518	350	558	34,651	86,152	-57,964
Seismic (SSE)	± 5,172	±6,541	±6,444	±27,636	±83,581	±88,064
Thrust	±37,978	±42,031	±40,982	±88,111	±303,787	±295,756
Pool Swell Impact/Drag	-94,460	30,896	25,763	1,200,053	-763,086	-2,421,706
Chugging	-54,874	39,112	36,704	379,747	1,346,730	-1,252,590

Table Notes:

1. Load units are in lbs for X and in-lbs for M.
2. Reference [7.4.9 Page 17 of 20]
3. SSE is conservatively used for EC 18.
4. The component is above water, so there is no SRV load
5. EC 25 = Dead Weight + Seismic (SSE) + Thrust + Pool Swell
6. EC 18 Load = Dead Weight + Seismic (OBE) + Thrust +Pool Swell.

For 0.0 ∆P Normal Operation, the loads would change with the factors from 1.7 ∆P Normal Operation to 0.0 ∆P Normal Operation [Section 5.1] as shown in Table D-24.

Table D-24 - VH Mitre Joint Loads at Node 16 Element 14 - 0.0 ∆P NO

Load	Factor	X1	X2	X3	M1	M2	M3
Dead Weight	1	-4,518	350	558	34,651	86,152	-57,964
Seismic (OBE)	0.54	±2,796	±3,536	±3,483	±14,938	±45,179	±47,602
Seismic (SSE)	1	±5,172	±6,541	±6,444	-/+27,636	±83,581	±88,064
Thrust	1.17	±44,434	±49,176	±47,949	±103,090	±355,431	±346,035
Pool Swell Impact/Drag	1.29	-121,853	39,856	33,234	1,548,068	-984,381	-3,124,001
Chugging	1	-54,874	39,112	36,704	379,747	1,346,730	-1,252,590

Table Notes:

1. Load units are in lbs. for X and in-lbs. for M.
2. Reference [7.4.9 Page 17 of 20]
3. Load Condition Adjustment Factors are given in Section 5.1
4. Earthquake Adjustment for OBE to SSE is given in Section 2.10.14

For EC 18, the above loads (dead weight, seismic (OBE), thrust and PS) were added for its absolute values or the 0.0 ∆P Normal Operation pool swell load case as in Table D-25. For EC 25, the above loads (dead weight, seismic (SSE), thrust and PS) were added for its absolute values or the 0.0 ∆P Normal Operation pool swell load case as in Table D-25.

Table D-25 - VH Mitre Joint Loads at Node 16 Element 14– PS Loads

0.0 ∆P PS NO	X1	X2	X3	M1	M2	M3
EC 18	173,601	92,918	85,224	1,700,748	1,471,143	3,575,601
EC 25	175,978	95,923	88,185	1,713,445	1,509,545	3,616,063

Table Notes:

1. Load units are in lbs. for X and in-lbs. for M.
2. The component is above water, so there is no SRV load

The principal stress can be calculated by the following equation using the above absolute values of the loads [7.4.9 Page 17 of 20]:

$$\sigma = \sqrt{[(\frac{X_1}{A} + \frac{m_r}{S})^2 + 4 * \left(\frac{m_1}{2S} + \frac{X_r}{A/2}\right)^2]}$$

Where:

$m_r = \sqrt{(m_2{}^2 + m_3)}$, $X_r = \sqrt{(X_2{}^2 + X_3{}^2)}$, A (44.97 in^2) is the area and S (641 in^3) is the section modulus [7.4.9 Page 10 of 20].

The maximum and minimum principal stresses were then calculated as:

$$\sigma_{abs} = 17{,}437psi \text{ For EC 25}$$

$$\sigma_{abs} = 17{,}037psi \text{ For EC18}$$

Then the load at 0.0 ∆P Normal Operation was then evaluated as in Table D-26.

Table D-26 - VH Mitre Joint EC18 and EC 25 Loads - 0.0 ∆P NO

	Item	Unit	Value	Reference
A	(P_L+P_B) - EC 25	psi	17,437	
B	(P_L+P_B) - EC 18	psi	17,037	
C	P_L+P_B SIF		1.23	[7.4.9 Page 17 of 20]
D	Pressure SIF		1.23	[7.4.9 Page 17 of 20]
E	Pressure	psi	1139	[7.4.9 Page 11 of 20]
F	Primary Stress EC25	Psi	22,849	=A*C+D*E
G	Primary Stress EC18	Psi	22,357	=B*C+D*E
H	S_{mc} for SA 516, Gr.70	psi	22,000	[7.4.9 Page 5 of 20] [Table 11]
I	Level B allowable 1.5*S_{mc}	psi	33,000	
J	S_Y for SA 516, Gr.70	psi	38,000	
K	Level C Allowable 1.5*S_Y	psi	57,000	
	Allowable/ Actual - EC 18		1.48	=I/G
	Allowable/ Actual - EC 25		2.50	=K/F

The results for the controlling stress in vent header at mitre are then updated as below:

Table D-27 - Controlling Stress in VH Mitre Joint – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Vent Header– Mitre Joint	18	Membrane + Bending	22,357 psi	33,000 psi	1.48
Vent Header– Mitre Joint	25	Membrane + Bending	22,849 psi	57,000 psi	2.50

Vent Header – Fatigue Evaluation

The fatigue analysis of the vent system was evaluated conservatively with all maximum stresses occur simultaneously at their maximum values as listed in PUAR shown in Table D-28 [7.3.2 Para. 4.4.9].

Table D-28 - Fatigue Stress in Vent Header Supports – Teledyne

Component	EC	Type of Stress	Actual	Allowable	Reference
Vent Header Support	21	Fatigue Stress Usage Factor	0.98	1.0	[7.3.2 Para. 4.4.9]

The Fatigue results reported by TES in the PUAR are based on Primary + Secondary Stress Range and are unaffected by changes to the PS loading per PUAAG Table 5-2 Note 3 as discussed in Section 2.3.

E. T-QUENCHER AND SUPPORT STRESS EVALUATION

T-Quencher

The controlling stress in the T-Quencher was listed in PUAR and TES SRV T-Quencher and Support Beam analysis as shown in Table E-1.

Table E-1 - Controlling Stress in T-Quencher Bifurcated Elbow – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
T-Quencher Bifurcated Elbow	25	Bending	26,292 psi	37,440 psi	[7.3.2 Para. 6.4.1] [7.4.17 Page 10 of 21]

The T-Quencher and Supports with SRVDL loads were analyzed using a STARDYNE Program finite element beam model for the 0.0 ΔP Load Conditions [7.4.17 Page 5 of 21].

The maximum design basis accident T-Quencher loads were at T-Quencher Bifurcated Elbow (Rams Head) Node 1505 as listed in Table E-2.

Table E-2 - Load Condition Stress in T-Quencher Bifurcated Elbow

Load Condition psi	0.0 ΔP Accident Condition	Load Condition Adjustment Factors	0.0 ΔP NO	References
Drag Load (CO/CH)	745	1.05	782	[7.4.17 Page 10 of 21]
Deadweight	242	1	242	[7.4.17 Page 10 of 21]
Thrust (SRV Blowdown)	13,969	1	13,969	[7.4.17 Page A-15 of A-15]
Thermal	5,366	1	5,366	[7.4.17 Page 10 of 21]
Seismic	2	1	2	[7.4.17 Page 10 of 21]
Internal Line Pressure	1,227	1	1,227	[7.4.17 Page 10 of 21]
Total	21,551		21,588	

Table Notes:

1. References: 7.4.17 Page 10 of 21 & A-15 of A-15, Section 5.1.
2. End cap loads are included in the Blowdown load from the Appendix.

3. PS 0.0 ∆P drag loads were compared to the CO/CH FSI drag loads and it was determined that the greater magnitude CO/CH loads would be conservatively used [7.4.17 Page 5 of 21]. However, the PS Drag shall be adjusted by 1.05 per Section 5.1. Therefore, increase the reported drag load by 1.05 to assure that this case is bounded.

The DBA bending stress due to end cap pressure also increases the T-Quencher stress by 22% based on Element 261 [7.4.17 Page A-6 of A-15]. Thus, the maximum DBA stress was then calculated as:

$$\sigma_{DBA} = 21{,}588 * 1.22 = 26{,}337\ psi$$

The material at bifurcated elbow of the T-Quencher is SA403 WP316L [7.4.17 Page 10 of 21]. The allowable stress value 2.4 S_H was calculated as given below [Sections 2.11.2 & 2.13]:

$$\sigma_A = 2.4 * S_h = 2.4 * 15{,}800 = 37{,}920\ psi$$

The results for the controlling stress in the T-Quencher are then updated in Table E-3.

Table E-3 - Controlling Stress in the T-Quencher Bifurcated Elbow DL – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
T-Quencher Bifurcated Elbow	25	Local Membrane + Bending	26,337 psi	37,920 psi	1.44

Submerged Portion - SRV Discharge Line

The controlling stress in submerged SRV DL was listed in PUAR and the TES SRV T-Quencher and Support Beam Analysis as shown in Table E-4.

Table E-4 - Controlling Stress in the Submerged Portion of Vertical SRV DL – TES

Component	EC	Type of Stress	Actual	Allowable	References
Submerged SRV DL Vertical Section Above Reducer	25	Pressure + Bending	25,085 psi	36,000 psi	[7.3.2 Para. 6.4.2] [7.4.17 Page 12 of 21]

The T-Quencher and Associated Supports with applied SRVDL loads were analyzed using a STARDYNE Program finite element beam model for the 0.0 ∆P Load Conditions [7.4.17 Page 5 of 21].

The maximum DBA SRVDL loads were tabulated at Element 261 as listed in Table E-5 [7.4.17 Page 12 of 21].

Table E-5 - Load Condition Stress in the Submerged Portion of Vertical SRV DL

Load, psi	0.0 ∆P Accident Condition	Load Condition Adjustment Factor	0.0 ∆P NO	References
Drag Load, CO/CH	4,266	1.05	4,279	[7.4.17 Page 12 of 21]
Deadweight	70	1	70	[7.4.17 Page 10 of 21]
Thrust (SRV Blowdown)	9,588	1	9,588	[7.4.17 Page A-6 of A-15]
Thermal	9,177	1	9,177	[7.4.17 Page 10 of 21]
Seismic	3	1	3	[7.4.17 Page 10 of 21]
Internal Pressure	1,980	1	1,980	[7.4.17 Page 10 of 21]
Total	25,085		25,298	

Table Notes:

1. PS 0.0 ∆P drag loads were compared to the CO/CH FSI drag loads and it was determined that the greater magnitude CO/CH loads would be conservatively used [7.4.17 Page 5 of 21]. However, the PS Drag shall be adjusted by 1.05 per Section 5.1. Therefore, increase the reported drag load by 1.05 to assure that this case is bounded.

The material at the SRV line is A106 Gr. B [7.4.17 Page 12 of 21]. The allowable stress is calculated per Sections 2.11.2 and 2.13:

$$\sigma_A = 2.4 * S_H = 2.4 * 17{,}100 = 41{,}040\ psi$$

The results for the controlling stress in the SRV line are then updated below in Table E-6.

Table E-6 - Controlling Stress in the Submerged Portion of Vertical SRV DL – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Submerged SRV Line Vertical Section Above Reducer	25	Bending	25,298 psi	41,040 psi	1.62

Tee-Quencher Support

The controlling stress in tee-quencher support was listed in PUAR and TES SRV T-Quencher and Support Beam Analysis as shown in Table E-7.

Table E-7 - Controlling Stress in T-Quencher Support – TES

Component	EC	Type of Stress	Actual	Allowable	References
T-Quencher Support at Brace	25	Pressure + Bending	10,729 psi	36,000 psi	[7.3.2 Para. 6.4.3] [7.4.17 Page 11 of 21]

The T-Quencher, Associated Support and SRVDL loads were analyzed with a STARDYNE Program finite element beam model at the 0.0 ∆P Load Conditions [7.4.17 Page 5 of 21].

The maximum DBA T-Quencher loads were taken at Nodes 1580 and 1590 for beam number 520 as listed in Table E-8 [7.4.17 Page 11 of 21].

Table E-8 - Controlling Stress in T-Quencher Support Calculation

Load psi	0.0 ΔP Accident Condition	Load Condition Adjustment Factor	0.0 ΔP NO
Drag Load CO/CH	2,027	1.05	2,128
Deadweight	129	1	129
Thrust (SRV Blowdown)	5,394	1	5,394
Thermal	460	1	460
Seismic	0	1	0
0.0 PS ↓ Download	124	1.11	138
LOCA Jet	660	1	660
Total	8,794		8,909

Table Notes:

1. References: 7.4.17 Page 11 of 21& Section 5.1
2. PS Loads were derived from the 0.0 ΔP ↓ Download Phase Accident Condition [7.4.17 Page 5 of 21]. The Load Condition Adjustment Factor for 0.0 ΔP NO is 1.11.
3. PS 0.0 ΔP drag loads were compared to the CO/CH FSI drag loads and it was determined that the greater magnitude CO/CH loads would be conservatively used [7.4.17 Page 5 of 21]. However, the PS Drag shall be adjusted by 1.05 per Section 5.1. Therefore, increase the reported drag load by 1.05 to assure that this case is bounded.

The DBA bending stress was also increased by 22% for element 261 to account for the end cap pressure bending load [7.4.17 Page A-6 of A-15]. Thus, the maximum DBA stress was then calculated as:

$$\sigma_{DBA} = 8{,}909 * 1.22 = 10{,}869\ psi$$

The material at the T-Quencher support is SA516 Gr.70 [7.4.17 Page 11 of 21]. The allowable stress was calculated per Sections 2.11.2 and 2.13 [7.5.4, Table 1A & 7.2.1, Section 5.4(4)]:

$$\sigma_A = 2.4 * S_H = 20{,}000 * 2.4 = 48{,}000\ psi$$

The results for the controlling stress in the T-Quencher support are then updated in Table E-9.

Table E-9 - Controlling Stress in T-Quencher Support – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Tee - Quencher Support at the Brace Connection	25	Bending	10,869 psi	48,000 psi	4.42

F. EMERGENCY CORE COOLING AND RCIC SYSTEM SUCTION STRAINERS

After the end of the Mk I Program, in 1998, larger suction strainers were installed in the Torus per NRC Bulletin 96-03 as discussed in Section 2.17. They include: 2 RHR, 2 CS, 1 HPCI and 1 RCIC strainer. The strainers were evaluated for Mk I Program hydrodynamic loads including CO and CH, SRV bubble, LOCA Jet and Bubble, and PS. The stress intensity in the perforated plate was then determined in accordance with ASME article A-8142-1 [Section 2.17].

Based on the discussion in Section 2.17, the individual load conditions (i.e., Torus Internal Loads) on the strainers will not change for 0.0 ΔP NO. The current strainer stress evaluation results listed below are from 7.4.22 for HPCI and RCIC and 7.4.67 for CS and RHR.

The summary of the maximum interaction ratios for the installed strainers are listed in Section 10.0 of the referenced calculations. The controlling location for the strainers is at the perforated plates.

X-225 A&B ECCS SUCTION STRAINER REVIEW

The clamshell design for the strainer is reviewed in A384.F02-19 [7.4.67]. Attachment E of the document contains the updated strainer and perforated plate evaluation for the clamshell design. The evaluation included both the clamshell protected and unprotected plate. The maximum IR for the Clamshell Design is reported in Section E 7.0 Conclusions: IR = 0.93. This IR is also reported in Section 10 Results. The Section 10 results also report a maximum IR = 0.94 for the perforated plate. However, this IR appears to be superseded by the Attachment E evaluation. It is noted that the Allowable Stress Values used are not the reconciled values. Per Section 5.1 of the calculation the material is A240 Tp 304 and S_H used in the calculation was 17.56 ksi. The S_H = 20 ksi per Section 2.13 for the reconciled material properties. The adjusted IR = 0.83 with consideration of the next most limiting IR listed. This represents a ratio of Allowable/ Actual Stress (or Load) of 1.20.

X-224 AND X-226 SUCTION STRAINER REVIEW

The maximum interaction ratio for HPCI and RCIC strainers is 0.92 for the primary membrane plus bending stress at perforated disk plates [7.4.22 Para. 10.0]. Per Section 5.1 of the calculation the material is A240 Tp 304 and S_H used in the calculation was 17.56 ksi. The S_H = 20 ksi per Section 2.13 for the reconciled material properties. The adjusted IR = 0.86 with consideration of the next most limiting IR listed. This represents a ratio of Allowable/ Actual Stress (or Load) of 1.16.

G. OTHER STRUCTURES

Catwalk Stress Evaluation

A partial catwalk for three of the torus bays exists and was analyzed by TES. The partial catwalk consists of a horizontal frame structure which supports sections of open grating. It is supported from the ring girders and fitted with handrails. The controlling stress in the partial catwalk was listed in PUAR and TES catwalk analysis as shown in Table G-1.

Table G-1 - Controlling Stress in Catwalk – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Main Frame	25	Axial + Bending	31,500 psi	56,700 psi	[7.3.2 Para. 7.1.3] [7.4.23 Page 133 of 355]
Support Columns and End Joints	25	Bending	56,600 psi*	56,700 psi	[7.3.2 Para. 7.1.3]
Welds to Ring Girder	25	Shear	27,903 psi	42,000 psi	[7.3.2 Para. 7.1.3] [7.4.23 Page 128 of 355]

Table Notes:

1. The actual stress for the support columns and end joints was identified as 56,600 psi not 42,765 psi listed in the TES Report per the catwalk calculation [7.4.23 Page 131 & 133 of 355].
2. The Service Level E Allowable Stress Values used were developed by TES based on limiting stress values to avoid the formation of a plastic hinge. [7.3.2 Para. 7.1.3 & 7.4.23 Page 84 of 355].

The internal structures including catwalk are non-safety-related elements which are not pressure retaining per PUAAG Para. 2.2.13 [7.2.1]. The service level limit is defined as Level E service limit when Level D service limit is exceeded [7.2.1 Para. 4.2.5]. The main frame and support columns and end joints stress was maintained below the stress at which a plastic hinge would form [7.3.2 Para. 7.1.3 & 7.4.23 Page 84 of 355]. The welds to ring girder were analyzed at 0.6 Su as the Service Level E Allowable Stress Value [7.4.23 Page 128 of 355 & Section 2.14].

Main Frame

The catwalk was modified with 2 additional (structural tubing) welded struts. The grating was also designated as requiring removal during operation to reduce the overall stress on the frame [7.4.23 Page 137 of 355 & 7.7.2 through 7.7.5]. The maximum stress for the modified main frame was determined from EC 25 in outboard catwalk support channel mid-span in the vent bay at the AZ 315° platform [7.4.23 Page 133 of 355]. The EC on the above the water structural elements includes 0.0 ΔP PS (Accident Condition), SRV, SSE and Weight Load Conditions [7.4.23 Page 86-87 & 133 of 355]. The 0.0 ΔP PS load consist of PS drag and Fallback loads [7.3.2 Para. 7.1.2]. The Load Condition Adjustment Factors for 0.0 ΔP NO PS are 1.05 and 1.0 for drag and fallback loads, respectively [Section 5.1, Table 13]. The SRV, SSE and Weight

Load Conditions will not be affected by 0.0 ΔP NO. Therefore, the maximum stress for the main frame is updated for 0.0 ΔP NO with the maximum factor of 1.05 as given below:

$$31.5\ ksi * 1.05 = 33.075\ ksi$$

Support Columns and End Joints

The submerged loadings on the support columns and end joints were calculated based on a fix-fix condition [7.4.23 Page 99 of 355]. The above the water load, PS Fallback, was analyzed on a STARDYNE FEM of the catwalk [7.4.23 Page 138 of 355]. The PS Impact and Drag occurs as the pool raises then the Froth and Fallback loads follow. In Table G-1 loads are conservatively combined by addition. The PS loading conditions can be combined less conservatively by SRSS as they do not occur simultaneously. The SSE and SRV loads can be combined less conservatively by SRSS as well. The 0.0 ΔP NO EC 25 is then recalculated in Table G-2.

Table G-2 - 0.0 ΔP NO Loads for Catwalk Support Columns and End Joint

	Load Condition	Pin-Pin Bending Stress psi	TES Adjustment Factor	Fix-Fix Bending	Adjustment Factor	0.0 ΔP NO Stress psi
A	PS Impact and Drag	63,565	0.625	39,728	1.05	41,715
B	SRV (A1.2)	16,345	0.667	10,902	1.00	10,902
C	SSE	1,596	0.667	1,065	1.00	1,065
D	Weight	-2,657	0.667	-1,772	1.00	-1,772
E	PS Fallback	-	-	2,400	1.00	2,400
	Total EC 25 Load ($\sqrt{(\sqrt{A^2+E^2})^2+(\sqrt{B^2+C^2})^2}+\lvert D\rvert$)					44,968

Table Notes:

1. The TES Adjustment Factor was applied to the FEA results rather than rerun the FEM with fix-fix joints.
2. The PS Fallback occurs well after the PS Impact and Drag Loading Conditions. Therefore, it is appropriate to SRSS the PS cases.
3. Table reference: 7.4.23 Page 99&138 of 355.

Welds to Ring Girder

The most severe loading for the welds to ring girder will occur on the tongue connection [7.4.23 Page 128 of 355]. The EC for 0.0 ΔP NO is calculated in Table G-3.

Table G-3 - 0.0 ΔP NO EC for Welds to Ring Girder

	Load Conditions	0.0 ΔP Accident Condition Load lbs	Load Condition Adjustment Factor	0.0 ΔP NO Load lbs
A	Diagonal Load Element 470	12,865	1.05	13,508
B	Pool Swell Impact and Drag	1,130	1.05	1,187
C	SRV	181	1.00	181
D	Resultant Load lbf	(A+B+C)		13,577
	Total Stress psi	2.158*D		29,300

Table Notes:

1. Table reference: 7.4.23 Page 124&128 of 355.
2. The 12,865 lbs was taken from the STARDYNE PS analysis of the Catwalk.
3. 2.158 x Resultant Load accounts for the offset loading direction on the attachment lug.

The results for the controlling stress in the catwalk are then updated below in Table G-4.

Table G-4 - Controlling Stress in Catwalk - 0.0 ΔP NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Main Frame	25	Axial +Bending	33,075 psi	56,700 psi	1.71
Support Columns and End Joints	25	Bending	44,968 psi	56,700 psi	1.26
Welds to Ring Girder	25	Shear	29,300 psi	42,000 psi	1.43

<u>Spray Header Stress Evaluation</u>

The internal spray header is attached to the ring girders and to a penetration on the shell. It is located at the top of the torus, above the VH [7.3.2, Figure 2-3]. The controlling stress in internal spray header was listed in PUAR and TES internal spray header analysis as shown in Table G-5:

Table G-5 - Controlling Stress in Spray Header, Supports and Attachment Welds – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Spray Header Piping – Tee at Branch Line	19	Bending	2,420 psi	1.8 S_H = 24,660 psi	[7.3.2 Para. 7.2.3 [7.4.38 Page 8 of 88]
Attachment Welds to Ring Girder – Support Hold Down Plate	19	Shear + Bending	14,427 psi	0.3 S_U = 18,000 psi	[7.3.2 Para. 7.2.3 [7.4.38 Page 9 of 88]
Welds to Ring Girder	19	Shear + Bending	1,160 psi	0.3 S_U = 18,000 psi	[7.3.2 Para. 7.2.3 [7.4.38 Page 9 of 88]

Table Notes:

1. The spray header is above the pool therefore SRV loads are not applicable.
2. The spray header material is A333 GR-1 with $S_H = 15.7\ ksi$ based on 2007 Code [7.4.38 Page 13 of 88, Section 2.13]. The new allowable is then calculated as; $1.8\ S_H = 1.8 * 15.7 = 28.26\ ksi$.
3. Welds are E70xx Electrode 0.3 S_U = 21,000 psi Section 2.14 not the 18,000 psi conservatively listed in the table.

The JAF internal spray header analysis used a STARDYNE model computer analysis and stress evaluation in accordance with Equation 9 of the ASME Code [7.4.38 Page 10 of 88]. For the Equation 9 evaluation, the EC 19 was evaluated for Load Conditions: metal plus water Weight, PS Froth load; PS shell motion at the 0.0 ∆P Accident Condition; and SSE EQ [7.4.38 Page 10 of 88]. Among all the dynamic loadings analyzed the only load increase from 0.0 ∆P Accident to 0.0 ∆P NO will be the PS shell motion at 0.0 ∆P NO with a Load Condition Adjustment Factor of 1.11 (i.e., use the ↓ Download Phase to obtain maximum motion) [Section 5.1]. The Froth load at 0.0 ∆P NO will be less than 1.7 ∆P NO, based on the load condition adjustment factors [Section 5.1]. Therefore, conservatively apply the adjustment factor of 1.11 to the TES calculated maximum stress. The allowable stress values are reconciled with the 2007 ASME code.

The maximum stress for the spray header piping evaluated by TES was at the tee at branch line, Element 1 Node 3R [7.4.38 Page 38 of 88].

The adjusted results for the controlling stress in the internal spray header are updated below in Table G-6:

Table G-6 - Controlling Stress in Spray Header, Supports and Attachment Welds – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Spray Header Piping – Tee at Branch Line	19	Bending	2,686 psi	28,260 psi	10.52
Attachment Welds to Ring Girder – Support Hold Down Plate	19	Shear + Bending	16,014 psi	21,000 psi	1.26
Welds to Ring Girder	19	Shear + Bending	1,288 psi	21,000 psi	16.30

Vent Pipe Bellows Displacement Evaluation

The vent pipe bellows forms the pressure seal between the vent pipe and torus allowing for relative motion between these parts. The maximum differential motion across the bellows was listed in PUAR and Teledyne vent pipe bellows/torus shell relative motion evaluation as shown in Table G-7.

Table G-7 - VP Bellows Drywell/ Torus Differential Displacements – TES

Component	EC	Type of Motion	Actual	Allowable	Reference
Vent Pipe Bellows	25	Axial Compression	.036 in	.375 in	[7.3.2 Para. 7.3.3] [7.4.39 Page 6 of 7]
Vent Pipe Bellows	25	Axial Extension	.036 in	1.125 in	[7.3.2 Para. 7.3.3] [7.4.39 Page 5-6 of 7]
Vent Pipe Bellows	25	Lateral Motion	.123 in	.625 in	[7.3.2 Para. 7.3.3] [7.4.39 Page 6 of 7]

The vent pipe bellows relative motion evaluation was performed with the 0.0 ∆P PS Accident Condition for evaluation of EC 25 [7.3.2 Para. 7.3.3 & 7.4.39 Page 4 of 7]. Although the 0.0 ∆P PS load had only slight impact and the stress was insignificant, a conservative Load Condition Adjustment Factor of 1.05 (i.e., use the ↑ Upload Phase as PS impacts the VH) is used to obtain the maximum displacement for 0.0 ∆P PS NO [7.3.2 Para. 7.3.3 & Section 5.1]. The 0.0 ∆P PS NO, maximum differential motion for the vent pipe bellows is then updated below in Table G-8.

Table G-8 - VP Bellows Drywell/ Torus Differential Displacements – 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Vent Pipe Bellow	25	Axial Compression	.038 in	.375 in	9.87
Vent Pipe Bellow	25	Axial Extension	.038 in	1.125 in	29.61
Vent Pipe Bellow	25	Lateral Motion	.129 in	.625 in	4.84

Monorail Stress Evaluation

The monorail is attached to the torus ring girders at about 45° above the water level. It is a non-containment related structure and therefore in the same category as the catwalk (Level E service limits). The controlling stress in the monorail was listed in PUAR and TES monorail analysis as shown in Table G-9:

Table G-9 - Controlling Stress in Monorail – TES

Component	EC	Type of Stress	Actual	Allowable	Reference
Monorail Beam	19	Bending	37,310 psi	42,280 psi	[7.3.2 Para. 7.4.3] [7.4.40 Page 6 of 38]
Monorail Build-up Column	19	Axial + Bending	54,160 psi	57,290 psi	[7.3.2 Para. 7.4.3] [7.4.40 Page 6 of 38]
Monorail Weld to Ring Girder	19	Bending + Tension	53,067 psi	57,290 psi	[7.3.2 Para. 7.4.3] [7.4.40 Page 6 of 38]

Table Notes:

1. The Service Level E Allowable Stresses are defined by the acceptable plastic hinge stress. A typical calculation is given in the Catwalk Calculation [7.4.23 Page 83 of 355]. The calculation is dependent upon material geometry and base metal material yield strength. The base metal includes A36 (S_Y = 36 ksi) and A516Gr70 (S_Y = 38 ksi).

The controlling EC 19 is a combination of Froth, Weight and SSE EQ, Load Conditions which will not change under 0.0 ∆P NO [Section 5.1]. The controlling loads all included a DLF of 1.10. Service Level E permits gross general structural deformations with some loss of dimensional stability, i.e. plastic deformation. The full plastic hinge stress was calculated based on a ratio with yield stress [7.4.40 Page 19 of 38]. Thus, the controlling stress will still be unchanged for 0.0 ∆P NO as shown below in Table G-10.

Table G-10 - Controlling Stress in Monorail Beam, Supports and Attachment welds, 0.0 ∆P NO

Component	EC	Type of Stress	Actual	Allowable	Allowable/ Actual
Monorail Beam	19	Bending	37,310 psi	42,280 psi	1.13
Monorail Build-up Column	19	Axial + Bending	54,160 psi	57,290 psi	1.06
Monorail Weld to Ring Girder	19	Bending + Tension	53,067 psi	57,290 psi	1.08

H. SAFETY RELIEF VALVE DISCHARGE LINES

See Section 5.10.1.

I. TORUS ATTACHED PIPING

X-214 HPCI Turbine Exhaust Piping

The calculation reviewed is Penetration X-214 R1, "Torus Attached Piping Analysis," July 1983 [7.4.24]. This calculation has been superseded by JAF-CALC-06-00030 [7.4.25] with the addition of a submerged sparger internal to the torus. However, a review of the original results was performed to facilitate evaluation and provide a better understanding of the review for the new results.

X-214 PIPE STRESS REVIEW – TES

Table I-1 - Reported Pipe Stress Results X-214 - TES

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	2805	1.0 S_H = 15,000
1a		P+N+OBE	4180	1.2 S_H = 18,000
1b		P+N+SRV	4053	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	11,477	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	10,564	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	21,139	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	16,442	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	13,853	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.24

Adjusted Pipe Stress Results from X-214

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-2.

Table I-2 - Individual Load Condition Contributions per EC X-214 - TES

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Allowable Stress Value psi
B31.1	Equation 8	Sustained P+N	2805	1.0 S_H = 15,000	17,100
1a		P+N+OBE	4180	1.2 S_H = 18,000	20,520
1b		P+N = 2805 SRV=1248	4053	1.2 S_H = 18,000	20,520
1c	3	P+N+EQ = 10,229 SRV = 1248	11477	1.8 S_H = 27,000	30,780
2 (2, 3)	16	P+N = 2805 0.0 ΔP External = 3968 Internal = 3791	10564	2.4 S_H = 36,000	41,040
3	21	P+N+EQ = 10,229 DBA CO = 10,910	21139	2.4 S_H = 36,000	41,040
4 (2, 3, 4)	25 - 1.7 ΔP	P+N+EQ = 10,229 SRV = 0 1.7 ΔP External = 2422 Internal = 3791	16442	2.4 S_H = 36,000	41,040
4 (2, 3 & 4)	25 – 0.0 ΔP (Accident)	P+N+EQ = 10,229 SRV = 0 0.0 ΔP External = 3968 Internal = 3791	17988	2.4 S_H = 36,000	41,040
4 (2, 3, 5, 6, 7 & 8)	25 – 0.0 ΔP (NO)	P+N+EQ = 10,229 SRV = 0 0.0 ΔP External = 3968 x 1.11 Internal = 3791 x 1.05	18614	2.4 S_H = 36,000	41,040
5 (4)	27	P+N+EQ = 10,229 SRV = 0 Post CH = 3624	13853	2.4 S_H = 36,000	41,040

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. The ECs are developed from the applicable Load Conditions from the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on the 0.0 ΔP Accident Condition from Computer Sequence Number HX3V49R, January 1983. This is also confirmed in the section where Internal Structure Submerged loads are calculated. LOCA loads used are based on the 0.0 ΔP Accident Condition.

4. SRV is not concurrent with CH/CO due to loss of RPV pressure with DBA events [Section 2.10].
5. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
6. Adjustment for Accident Condition 0.0 ΔP PS Structure loading 1.05 for Normal Operation [Section 5.1 Table 13].
7. Adjustment for Accident Condition 0.0 ΔP PS Froth and Fallback loading 1.00 for Normal Operation [Section 5.1 Table 13].
8. S_H the allowable stress value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ΔP Torus External Piping stress and understanding that the maximum Torus Internal Piping stress used for both EC 16 and 25 was for the 0.0 ΔP Accident Condition the total EC 25 stress is 18614 and EC 21 DBA CO remains the controlling EC (21139 psi) by approximately 14%. Allowable/ Actual Ratio = 41,040/21,139 =1.94.

X-214 PIPE SUPPORT REVIEW - TES

Pipe support loads and displacements were tabulated for the PS and CO/CH load cases (Table I-3) [7.4.24 Page 4-5 of 39].

Table I-3 - PS and CO/CH load cases at Pipe Support X-214 - TES

Support Node Number	Load Condition	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs	Ratio
75	PS		854					
	CO/CH		1806					2.1
90	PS			708				
	CO/CH			2390				3.4
115	PS		168					
	CO/CH		595					3.5
180	PS			289				
	CO/CH			1142				4.0
186	PS	478						
	CO/CH	1738						3.6
190	PS			239				
	CO/CH			912				3.8
235	PS	10	79	8	2959	1017	207	
	CO/CH	38	295	29	1100	3678	855	
		3.8	3.7	3.6	0.4	3.6	4.1	3.2

Based on the tabulation provided by the calculation and included above to facilitate review the support loads due to the 0.0 ΔP PS case are significantly smaller than those from the CO/CH case. CO/CH will bound for normal operation at 0.0 ΔP PS.

X-214 PIPE PENETRATION REVIEW - TES

The torus shell penetration X-214 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2& 7.4.18].

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and therefore only EC21 results are evaluated and reported. Review the previous results and determine if the assumption that EC 21is bounding still applies (Table I-4 to Table I-8).

Table I-4 - Reported Penetration Stress Results X-214 - TES

X-214	Location	Stress psi	Reported psi	Reconciled (1) psi
P_L	Torus Penetration	15325	$1.5S_{MC}$ = 28,900	33,000
P_M	Nozzle	11107	$1.0S_{MC}$ = 19,300	22,000

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported allowable stresses are from 7.4.24 Page 26 and 29 of 39.

Table I-5 - Reported Individual Penetration Loads X-214 - TES

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
DW	-200	2290	0	579	-240	20
TH	-5720	732	-893	-13200	263	3310
SSE	1670	1510	2660	123010	6250	1280
PS1 0.0 ΔP Accident	7318	1629	1220	40455	18499	5272
PS2 1.7 ΔP NO	3424	577	322	9299	8349	2232
CO	10004	3620	2885	163390	7390	12755
CH	1912	1077	781	29445	1424	2093
SRV	1735	1114	440	13218	2554	7275
CO/CH Lateral	930	4850	2003	95660	300	1000
CO/CH Long	330	511	12700	512900	3000	600
CO/CH Vert/Cir	255	2045	651	29318	100	100
PS Long	15	21	7306	86600	1000	15
PS Vert/Cir	272	6048	0	1930	7	1000

Table I-6 - PS Load Adjusted for 0.0 ΔP Normal Operation X-214 – TES

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
PS1 0.0 ΔP Accident	7318	1629	1220	40455	18499	5272
PS1 0.0 ΔP NO	8123	1808	1354	44905	20534	5852
PS Long Accident	15	21	7306	86600	1000	15
PS Long NO	16	22	7671	90930	1050	16
PS Vert/Cir Accident	272	6048	0	1930	7	1000
PS Vert/Cir NO	286	6350	0	2027	7	1050

Table I-7 - Reported ECs – Forces and Moments X-214 - TES

EC	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	9669	9239	4769	308526	7471	11338
16	N+TH+0.0 ΔP PS	13510	10699	2113	174964	19009	9602
21	N+TH+SSE+CO	16981	11626	6458	419351	10413	17144
25	N+TH+SSE+SRV+1.7 ΔP PS	10351	9908	3608	256806	11246	11393

Table I-8 - Adjusted ECs – Forces and Moments X-214 - TES

EC	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	9669	9239	4769	308526	7471	11338
16 (1 & 3)	N+TH+0.0 ΔP PS	14329	11181	2613	183745	21094	10232
21	N+TH+SSE+CO	16981	11626	6458	419351	10413	17144
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ΔP PS	15064	11442	5006	296743	23481	15063

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.05 [Section 5.1 Table 13].
3. Internal Submerged Loading is combined by SRSS and added absolutely to External Loading

4. Event Combinations were adjusted by adding the difference between the 1.7 ΔP Normal Operation and the 0.0 ΔP Normal Operation PS internal and external loads.

Based on a review of the Table I-8 - Adjusted Event Combinations – Forces and Moments the DBA CO EC is the bounding Event Combination for Normal Operation with 0.0 ΔP.

X-214 BRANCH LINE REVIEW - TES

2"-SLP-152-49

Table I-9 - Reported Stress Results from X-214 for 2"-SLP-152-49 - TES

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	1041	1.0 S_H = 15,000
1a		P+N+OBE	1545	1.2 S_H = 18,000
1b		P+N+SRV	1774	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	2386	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP	5393	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	16309	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP	5299	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	11282	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.24 Page 7 of 8.

Table I-10 - Individual Load Condition Contributions per EC from X-214 for 2”-SLP-152-49 - TES

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Allowable Stress Value psi
B31.1	Equation 8	Sustained P+N	1041	1.0 S_H = 15,000	17,100
1a		P+N+OBE	1545	1.2 S_H = 18,000	20,520
1b		P+N = 1041 SRV=733	1774	1.2 S_H = 18,000	20,520
1c	3	P+N+EQ = 1653 SRV = 733	2386	1.8 S_H = 27,000	30,780
2 (2, 3)	16	P+N = 1041 0.0 ΔP External = 1774 Internal = 2578	5393	2.4 S_H = 36,000	41040
3	21	P+N+EQ = 1853 DBA CO = 6902 Internal CH = 7754	16309	2.4 S_H = 36,000	41040
4 (2, 3, 4)	25 - 1.7 ΔP	P+N+EQ = 1653 1.7 ΔP External + SRV = 1068 Internal = 2578	5299	2.4 S_H = 36,000	41040
4 (2, 3 & 4)	25 – 0.0 ΔP (Accident)	P+N+EQ = 1653 0.0 ΔP External = 1774 Internal = 2578	6005	2.4 S_H = 36,000	41040
4 (2, 3, 5, 6, 7 & 8)	25 – 0.0 ΔP (NO)	P+N+EQ = 1653 SRV = 0 0.0 ΔP External = 1774 x 1.11 Internal = 2578 x 1.05	6329	2.4 S_H = 36,000	41040
5 (4)	27	P+N+EQ = 1653 SRV = 0 Post CH = 1875 Internal CO/CH = 7754	11282	2.4 S_H = 36,000	41040

Based on the information provided in the calculation EC 21 continues to be bounding for this Branch Line.

1”-WO-152-48

Table I-11 - Reported Stress Results from X-214 for 1”-WO-152-48 - TES

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	2349	1.0 S_H = 15,000
1a		P+N+OBE	4287	1.2 S_H = 18,000
1b		P+N+SRV	2620	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	7857	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP	3218	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	9778	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP	8287	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	8749	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.24 Page 8 of 8.

Table I-12 - Individual Load Condition Contributions per EC from X-214 for 1"-WO-152-48 - TES

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Allowable Stress Value psi
B31.1	Equation 8	Sustained P+N	2349	1.0 S_H = 15,000	17,100
1a		P+N+OBE	4287	1.2 S_H = 18,000	20,520
1b		P+N = 2349 SRV=271	2620	1.2 S_H = 18,000	20,520
1c	3	P+N+EQ = 7586 SRV = 271	7857	1.8 S_H = 27,000	30,780
2	16	P+N = 2349 0.0 ΔP External = 678 Internal = 191	3218	2.4 S_H = 36,000	41040
3	21	P+N+EQ = 7586 DBA CO = 1534 Internal CH = 658	9778	2.4 S_H = 36,000	41040
4	25 – 1.7 ΔP	P+N+EQ = 7586 1.7 ΔP External + SRV = 510 Internal = 191	8287	2.4 S_H = 36,000	41040
4	25 – 0.0 ΔP (Accident)	P+N+EQ = 7586 0.0 ΔP External = 678 Internal = 191	8455	2.4 S_H = 36,000	41040
4	25 – 0.0 ΔP NO	P+N+EQ = 7586 0.0 ΔP External = 678 x 1.11 Internal = 191 x 1.05	8539	2.4 S_H = 36,000	41040
5	27	P+N+EQ = 7586 Post CH = 505 Internal CO/CH = 658	8749	2.4 S_H = 36,000	41040

Based on the information provided in the calculation EC 21 continues to be bounding for this Branch Line.

Summary of the TAP stress change in EC 25 from 1.7 ΔP to 0.0 ΔP NO

Table I-13 - EC 25 from 1.7 ΔP to NO 0.0 ΔP Update X-214 - TES

EC 25	1.7 ΔP psi	0.0 ΔP psi	0.0 ΔP NO/ 1.7 ΔP
X-214 Piping	16442	18614	1.32
2"-SLP-152-49	5299	6329	1.19
1"-WO-152-48	8287	8539	1.03

The maximum increase of 32% as anticipated is at the Torus Penetration X-214.

The piping stress at the valves in the piping system would be anticipated to have a maximum increase of 32% as well. Demonstration of acceptability for valves is to maintain local stress results below Service Level B Allowable Stress Value of 1.2S_H as shown in Table I-14.

Table I-14 - VGW-15AN and VCW-15AN EC25 Valve Analysis X-214 - TES

Valve Designation	EC 25 1.7 ΔP psi	EC 25 x 1.32 psi	1.2 S_H psi	Allowable/ Actual
VGW-15AN	11795	15569	20520	1.32
VCW-15AN	14515	19160	20520	1.07
VCW-15AN	13830	18256	20520	1.12

Table Notes:

1. Reference: 7.4.24 Page 1 of 5.

Adequate stress margin exists to demonstrate that all valves will perform their design function using the estimated EC 25 0.0 ΔP PS Normal Operation pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B.

X-214 PIPE STRESS REVIEW w/SPARGER MODIFICATION JAF-CALC-06-00030

With the addition of a submerged Sparger internal to the torus, the X-214 HPCI turbine exhaust piping was recalculated in the JAF-CALC-06-00030 [7.4.25]. The transient steam blowdown stresses associated with operation of the HPCI Turbine Steam Exhaust System were included in the combinations 1b, 1c, 3 and 5. In these combinations, the steam blowdown stresses and the seismic stresses were combined with the absolute sum of the Mark I dynamic loads by the SRSS method [7.4.25 Page 18 of 597]. Load Combination 3 has been separated into Load Combination 3a and 3b. Combination 3a includes Design Basis Accident (DBA) Condensation Oscillation (CO) as before, but 3b substitutes Pre Chug for DBA CO with steam blowdown stress included.

Table I-15 - Reported Pipe Stress Results X-214 - JAF-CALC-06-00030

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	1,804	1.0 S_H = 15,000
1a		P+N+OBE	17,958	1.2 S_H = 18,000
1b		P+N+SRV+blowdown	16,864	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV+blowdown	24,026	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	8,922	2.4 S_H = 36,000
3a	21	P+N+EQ+DBA CO	21,164	2.4 S_H = 36,000
3b	21	P+N+EQ+Pre CH+blowdown	25,399	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	20,400	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+PostCH +blowdown	27,071	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.25

Adjusted Pipe Stress Results from X-214

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-16:

Table I-16 - Individual Load Condition Contributions per EC X-214 - JAF-CALC-06-00030

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Allowable Stress Value psi
B31.1	Equation 8	Sustained P+N	1,804	1.0 S_H = 15,000	17,100
1a		P+N+OBE	17,958	1.2 S_H = 18,000	20,520
1b		P+N = 1804 SRV=3818 Blowdown=14,567	16,864	1.2 S_H = 18,000	20,520
1c	3	P+N = 1804 EQ = 16,340 SRV=3818 Blowdown=14,567	24,026	1.8 S_H = 27,000	30,780
2	16	P+N = 1804 0.0 ΔP =7118 External=2511 Internal =4607	8,922	2.4 S_H = 36,000	41,040
3a	21	P+N = 1804 EQ = 16,340 DBA CO = 10,382	21,163	2.4 S_H = 36,000	41,040
3b	21	P+N = 1804 EQ = 16,340 Pre CH = 8,803 Blowdown = 14,567	25,399	2.4 S_H = 36,000	41,040
4	25 - 1.7 ΔP	P+N = 1804 EQ = 16,340 SRV = 3818 1.7 ΔP = 5,059	20,400	2.4 S_H = 36,000	41,040
4	25 – 0.0 ΔP (Accident)	P+N = 1804 EQ = 16,340 SRV = 3818 0.0 ΔP = 7118	21,466	2.4 S_H = 36,000	41,040
4	25 – 0.0 ΔP (NO)	P+N = 1804 EQ = 16,340 0.0 ΔP = 7625 External = 2511 x 1.11 Internal = 4607 x 1.05	21,752	2.4 S_H = 36,000	41,040
5	27	P+N = 1804 EQ = 16,340 SRV = 3,818 Post CH = 8,798 Blowdown = 14,567	27,071	2.4 S_H = 36,000	41,040

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. The ECs are developed from the applicable Load Conditions from both the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on the 0.0 ΔP Accident Condition [7.4.25 Page 20 of 597]. This is also confirmed in the section where Internal Structure Submerged loads are calculated. LOCA loads used are based on 0.0 ΔP Accident Condition.
4. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
5. Adjustment for Accident Condition 0.0 ΔP PS Structure loading 1.05 for Normal Operation [Section 5.1 Table 13].
6. Adjustment for Accident Condition 0.0 ΔP PS Froth and Fallback loading 1.00 for Normal Operation [Section 5.1 Table 13].
7. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ΔP Torus External Piping stress and understanding that the maximum Torus Internal Piping stress used for both EC 16 and 25 was 0.0 ΔP Accident Condition adjusted for NO, the total EC 25 stress is 21752 and EC 27 Post CH remains the controlling EC (27071 psi) by approximately 24% with an allowable/actual ratio of 41040/27071=1.52.

X-214 PIPE SUPPORT REVIEW w/SPARGER MODIFICATION JAF-CALC-06-00030

There is no SRV loading when steam is not available for HPCI Operation. Pipe support loads were then tabulated for the PS and DBACO load cases (Table I-17) [7.4.24 Page 4-5 of 39].

Table I-17 - PS and DBACO Load Conditions at Pipe Support (unit: lbf) X-214 - JAF-CALC-06-00030

Support	PFSK-2594	PSFK-2247	PFSK-1987	PFSK-1958	PFSK-1955	PFSK-2223
Node No.	75	90	115	180	190	186
DBACO	6692	9548	890	0	352	3964
0.0 ΔP PS Accident Condition	4267	13865	574	0	254	2135
0.0 ΔP PS NO (0.0 ΔP PS Accident Condition x 1.11)	4736	15075	637	0	282	2370
0.0 ΔP PS NO/ DBACO	0.71	1.58	0.72	0.00	0.80	0.60

Based on the tabulation provided by the calculation and included above to facilitate review most of the support loads due to the 0.0 ΔP PS case are smaller than those from the DBACO case. DBACO loading will bound the results for 0.0 ΔP PS NO except for PSFK-2247 below:

Table I-18 - 0.0 ΔP PS for Pipe Support PSFK-2247 X-214 - JAF-CALC-06-00030

Load, lbf	0.0 PS Accident	Factor	0.0 PS NO
PS Drag R	2625	1.05	2756
PS Drag L	121	1.05	127
PS Fallback	2867	1	2867
PS Impact	702	1.05	737
PS External	10998	1.11	12208
Total PS	13865		15075

Table Notes:

1. Reference no.: 7.4.25 Page 67 of 597.

For pipe support PSFK-2247 at node 90, the DBACO load (9548 lbf) is less than the 0.0 ΔP PS Accident Condition (13865 lbf). Thus the 0.0 ΔP PS for the support is reevaluated as in Table I-18. The total EC 25 load at 0.0 ΔP PS NO was then calculated as the SRSS of the 0.0 ΔP PS, EQ and SRV loads, 15075, 28689, and 2809, respectively to be 32,530 lbf. The design allowable loads are as follows:

Table I-19 - 0.0 ΔP PS NO for Pipe Support PSFK-2247 X-214 -- JAF-CALC-06-00030

Component	Actual	Allowable	Allowable/ Actual
Concrete Anchors	32,530 lbs	41046 lbs	1.26
Wall Plate	23,584 psi	27,000 psi	1.14
Welds	12,270 psi	21,000 psi	1.71
Welded Pipe Attachment	32530 lbs	1.33 x 30,971 = 41191 lbs	1.27

Table Notes:

1. [7.4.26 Page 8 of 16].
2. Wall Plate: Fb = (32530 lbs/2) (3.625 in)/2.5 in^3 = 23584 psi
3. Welds fw = 32530 lbs/15 in x 0.707 x 0.25 in = 12,270 psi
4. Per the PUAAG Table 5-2 all ECs with PS loading are ASME Code Service Level B [7.2.1, Table 5-2]. Since the original calculation evaluated the support for Service Level A for the previously controlling DBACO EC, the Level B Weld Allowable Stress Value may be used for the PS EC. The Service Level B Allowable Stress Value per Section 2.14 is 1.33 x Service Level A Allowable Stress Value.

X-214 PIPE PENETRATION REVIEW w/SPARGER MODIFICATION JAF-CALC-06-00030

The torus shell penetration X-214 was evaluated based on the piping model at the penetration node 20 [7.4.25 Page 25 of 597]

EC15 and EC21 were considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and therefore only EC15 and EC21 results are evaluated and reported. Review the previous results and determine if the assumption that EC15 and EC 21are bounding still applies (Table I-20 to Table I-24).

Table I-20 - Reported Penetration Stress Results X-214 - JAF-CALC-06-00030

X-214	Location	EC15 Stress psi	EC21 Stress psi	Reported psi	Reconciled (1) psi	Reconciled/ Max Stress
P_L	Torus Penetration	14907	14527	$1.5S_{MC}$ = 28,900	33,000	2.27
P_M	Nozzle	11214	11093	$1.0S_{MC}$ = 19,300	22,000	1.96

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported allowable stresses were from 7.4.25 Page 37, 39, 47, and 49 of 597.

Table I-21 - Reported Individual Penetration Loads X-214 - JAF-CALC-06-00030

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
DW	-273	4092	12	2352	-336	-324
TH	-1484	412	140	-56304	-3072	3012
EQ	12608	19353	2008	101292	768	6384
PS1 (0.0 ΔP) Accident	4094	3608	711	37812	180	984
PS2 (1.7 ΔP)	1365	756	161	9804	72	168
CO	1533	2907	1053	44520	96	744
CH	433	609	227	9672	48	144
SRV	1055	4419	276	17040	96	1380
CO/CH Radial	2046	10268	10	9828	120	3408
CO/CH Long	72	246	10190	536868	3576	60
CO/CH Vert	2046	3250	0	984	12	336
PS Drag (Radial)	988	5034	5	4920	60	1704
PS Fallback	1077	6903	5	3888	60	1476

Table I-22 - PS Load Adjusted for 0.0 ∆P Normal Operation X-214 - JAF-CALC-06-00030

Load Conditions	Fx lbs	Fy lbs	Fy lbs	Mx in-lbs	Mx in-lbs	Mx in-lbs
PS1 (0.0 ∆P) Accident	4094	3608	711	37812	180	984
PS1 (0.0 ∆P) Normal Operation	4544	4005	789	41971	200	1092
PS Drag Accident	988	5034	5	4920	60	1704
PS Fallback Accident	1077	6903	5	3888	60	1476
Max PS Fallback/Drag Accident	1077	6903	5	4920	60	1704
Max PS Fallback/Drag Normal	1131	7248	5	5166	63	1789

Table I-23 - Reported Event Combinations – Forces and Moments X-214 - JAF-CALC-06-00030

EC	Load Conditions	Fx lbs	Fy lbs	Fy lbs	Mx in-lbs	Mx in-lbs	Mx in-lbs
15	N+TH+SSE+SRV+CH	14939	34085	18452	614941	5244	11123
16	N+TH+0.0 ∆P PS	6928	15015	868	101388	3648	6024
21	N+TH+SSE+CO	14863	27899	2424	173607	4206	10951
25	N+TH+SSE+SRV+1.7 ∆P PS	14643	25781	2186	162421	4193	10130

Table I-24 - Adjusted Event Combinations – Forces and Moments X-214 - JAF-CALC-06-00030

EC	Load Conditions	Fx lbs	Fy lbs	Fy lbs	Mx in-lbs	Mx in-lbs	Mx in-lbs
15	N+TH+SSE+SRV+CH	14939	34085	18452	614941	5244	11123
16 (1 & 3)	N+TH+0.0 ∆P PS	7432	15757	946	105793	3671	6217
21	N+TH+SSE+CO	14863	27899	2424	173607	4206	10951
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ∆P PS	15624	27323	2329	171671	4225	10475

Table Notes:

1. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. 0.0 ∆P Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.05 [Section 5.1 Table 13].

3. Internal Submerged Loading is added absolutely to External Loading

Based on a review of the Table I-24- Adjusted Event Combinations – Forces and Moments the EC15 or EC 21 is the bounding Event Combination for Normal Operation with 0.0 ΔP.

X-214 BRANCH LINE REVIEW w/SPARGER MODIFICATION JAF-CALC-06-00030

For the HPCI Steam Exhaust Piping, there are two branch piping lines. These are 2"-SLP-152-49 attached to node 21 of the piping model and 1"-WD-152-48 attached to node 90 of the piping model. The displacements at the connection points for 5 ECs have been calculated from individual load displacement Table I-25, as shown in Table I-26 [7.4.25 Page 64-65 of 597].

Table I-25 - Branch Line Displacement by Load X-214 - JAF-CALC-06-00030

Branch	2"-SLP-152-49			1"-WO-152-48		
Displacement, inch	Δx	Δy	Δz	Δx	Δy	Δz
N	-0.001	-0.001	0.003	-0.018	-0.009	0.003
Thermal Positive	0	0.094	0	0	0.005	0
Thermal Negative	-0.081	0	-0.449	-0.238	-0.034	-0.756
EQ	0.015	0.02	0.138	0.105	0.025	0.135
PS1 0.0 ΔP PS	0.007	0.007	0.066	0.024	0.005	0.013
PS1 x 1.11	0.008	0.008	0.073	0.044	0.01	0.066
SRV	0.004	0.003	0.013	0.049	0.011	0.073
EC4 0.0 ΔP PS NO - Max	0.037	0.138	0.328	0.238	0.055	0.323
EC4 0.0 ΔP PS NO - Min	-0.120	-0.046	-0.771	-0.512	-0.102	-1.073

Table I-26 - Displacement for 5 ECs of Branch Lines X-214 - JAF-CALC-06-00030

Displacement, in		2”-SLP-152-49			1”-WO-152-48		
		Δx	Δy	Δz	Δx	Δy	Δz
EC 1	Max	0.036	0.135	0.295	0.227	0.054	0.289
	Min	-0.119	-0.043	-0.736	-0.501	-0.101	-1.039
EC 2	Max	0.032	0.135	0.309	0.21	0.05	0.304
	Min	-0.115	-0.043	-0.752	-0.484	-0.097	-1.054
EC 3	Max	0.044	0.139	0.323	0.273	0.07	0.316
	Min	-0.127	-0.047	-0.766	-0.547	-0.117	-1.066
EC 4 1.7 ΔP PS	Max	0.035	0.135	0.293	0.225	0.052	0.287
	Min	-0.118	-0.043	-0.736	-0.499	-0.099	-1.037
EC 4 0.0 ΔP PS NO	Max	0.037	0.138	0.328	0.238	0.055	0.323
	Min	-0.120	-0.046	-0.771	-0.512	-0.102	-1.073
EC 5	Max	0.051	0.141	0.320	0.304	0.074	0.315
	Min	-0.134	-0.049	-0.763	-0.578	-0.121	-1.035

Based on a review of EC 4 and EC 5, EC 5 still is the bounding Event Combination for Normal Operation with 0.0 ΔP.

Table I-27 - Branch Line Stress Results - Controlling EC 5 X-214 - JAF-CALC-06-00030

EC 27 Post Chug + Steam Blowdown	Stress psi	2.4 S_H psi	Allowable/ Actual
2”-SLP-152-49	5,247	41,040	7.82
1”-WO-152-48	15,748	41,040	2.61

Table Notes:

1. Reference: [7.4.25 Page 64-65 of 597]
2. Material A106 Gr B [7.4.25 Page 17 of 597]

X-214 VALVE ACCELERATION REVIEW w/SPARGER MODIFICATION JAF-CALC-06-00030

The three valves were evaluated for the accelerations for each of the dynamic load conditions. The largest accelerations come from a combination of maximum seismic, SRV, Chug, and Steam Blowdown [7.4.25 Page 72 of 597]. Steam blowdown load is still bounding 0.0 ΔP PS as shown in Table I-28.

Table I-28 - VGW-15AN and VCW-15AN Valve Acceleration Analysis X-214 - JAF-CALC-06-00030

VALVE ACCELERATIONS g's	16VGW-15AN		16VCW-15AN		20VCW-15AN	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
0.0 ΔP Pool Swell	1.26	0.10	1.26	0.05	1.26	0.06
Steam Blowdown	4.60	1.14	3.90	0.62	2.49	0.62
Allowable/Actual	3.7	11.4	3.1	12.4	2.0	10.3

Table I-29 - X-214 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	27	Post CH	1.52
Support	25	0.0 ΔP PS NO	1.14
Penetration	15 or 21	DBA CO	1.96
Branch Line	27	Post CH	2.61
Valves	27	Steam Blowdown	2.00

X-226 HPCI Pump Suction Piping

The calculation reviewed is Penetration X-226 R0, “Torus Attached Piping Analysis,” July 1983 [7.4.27]. With the ECCS and RCIC strainers upgrade in 1998, this calculation has been superseded by A384.F02-13 R1 [7.4.44] with the strainer attachment at the penetration. However, a review of the original results was performed to facilitate evaluation and provide a better understanding of the review for the new results.

X-226 PIPE STRESS REVIEW - TES

Table I-30 - Reported Pipe Stress Results X-226 - TES

TES TAP	EC	Load Conditions	Pipe Stress psi	Allowable Stress Value psi
B31.1	Equation 8	Sustained	6,374	1.0 S_H = 15,000
1a		P+N+OBE	12,737	1.2 S_H = 18,000
1b		P+N+SRV	8,373	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	15,306	1.8 S_H = 27,000
2	16	P+N+0.0 ∆P PS	29,480	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	17,439	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ∆P PS	26,433	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	16,052	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.27 Section VIII Page 7 of 10

Adjusted Pipe Stress Results from X-226

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-31:

Table I-31 - Individual Load Condition Contributions per EC X-226 - TES

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	Allowable Stress Value psi	Allowable Stress Value psi Reconciled
B31.1	Equation 8	Sustained P+N	6374	1.0 S_H = 15,000	17,100
1a		P+N+OBE	12,737	1.2 S_H = 18,000	20,520
1b		P+N = 6374 SRV=1999	8,373	1.2 S_H = 18,000	20,520
1c	3	P+N = 6374 EQ = 6933 SRV = 1999	15,306	1.8 S_H = 27,000	30,780
2	16	P+N = 6374 0.0 ΔP PS External = 13577 Internal = 9529	29,480	2.4 S_H = 36,000	41,040
3	21	P+N+EQ = 13307 DBA CO = 4132	17,439	2.4 S_H = 36,000	41,040
4 (2, 3, 4)	25 - 1.7 ΔP NO	P+N+EQ = 13307 SRV = 0 1.7 ΔP PS External = 3597 Internal = 9529	26,433	2.4 S_H = 36,000	41,040
4 (2, 3 & 4)	25 – 0.0 ΔP (Accident)	P+N+EQ = 13307 SRV = 0 0.0 ΔP PS External = 13577 Internal = 9529	36,413	2.4 S_H = 36,000	41,040
4 (2, 3, 5, 6, 7 & 8)	25 – 0.0 ΔP (NO)	P+N+EQ = 13307 SRV = 0 0.0 ΔP PS External = 13577 x 1.11 Internal = 9529 x 1.05	38,383	2.4 S_H = 36,000	41,040
5 (4)	27	P+N+EQ = 13307 SRV + Post CH = 2745	16,052	2.4 S_H = 36,000	41,040

Table Notes:

1. The location of maximum stress in the piping system may vary for each EC
2. PS is the Load Combination from both the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on 0.0 ΔP from Computer Sequence Number HX3TD5V, March 1983. This is also confirmed in the section where Internal Structure Submerged loads are calculated. LOCA loads used are based on 0.0 ΔP.
4. SRV is not concurrent with CH/CO due to loss of RPV pressure with DBA events [Section 2.10]. The TES results did not include SRV for EC 25 the PS NO case.

5. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
6. Adjustment for Accident Condition 0.0 ΔP PS Impact and Drag on Submerged Structure loading 1.05 for Normal Operation [Section 5.1 Table 13]. This is conservative as it appears that the applied loading is LOCA Jet and Bubble on Page 35 of 39 "Submerged Structure Loads.".
7. Adjustment for Accident Condition 0.0 ΔP PS Froth and Fallback loading 1.00 for Normal Operation [Section 5.1 Table 13].
8. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ΔP Torus External Piping stress and understanding that the maximum Torus Internal Piping stress used for both EC 16 and 25 was 0.0 ΔP the total EC 25 stress is 38,383 psi and EC 25 becomes the controlling EC in replace of the original controlling case EC 16.

X-226 PIPE SUPPORT REVIEW - TES

Pipe support loads and displacements were tabulated for the PS load cases from Computer Sequence Number HX3RG43, March 1983 (Table I-32) [7.4.27 Page 4 of 39].

Table I-32 - PS load cases at Pipe Support X-226 - TES

Support Node Number	Load Condition	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
65	PS		3933				
100	PS		1731				
106	PS	4767					
220	PS	2118	314	764	20971	109320	41541
300	PS	375					
310	PS		113				
330	PS		182				
370	PS		182				

Based results TES reported that the CO/CH support loads were considered negligible and not listed. The PS loads listed above will increase by 11% based on the PS ↓ Download Phase Load Condition Adjustment Factor from 0.0 ΔP Accident Condition to 0.0 ΔP NO Section 5.1.

Note that the original support designs including those designed by TES generally met Service Level A for Occasional Loading. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

X-226 PIPE PENETRATION REVIEW - TES

The torus shell penetration X-226 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 16 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results. The maximum free shell stresses occur for EC 21 DBACO. Based on a review of the maximum torus free shell in Attachment A, the PS free shell stresses are bounded by EC 21.

Table I-33 - Reported Penetration Stress Results X-226 - TES

X-226	Location	Stress, psi	Reported Allowable Stress, psi	Reconciled Allowable Stress, psi (1)	Allowable/ Actual
P_L	Torus Penetration	18654	$1.5S_{MC}$ = 28,900	33,000	1.77
P_M	Nozzle	13643	$1.0S_{MC}$ = 19,300	22,000	1.61

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.27 Page 25 and 28 of 39.

Table I-34 - Reported Individual Penetration Loads - X-226 - TES

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
DW	1289	-1357	2	-14472	-7080	-10248
TH	-979	608	-439	9900	-59700	19944
EQ	2889	2760	1784	88632	91824	18828
SRV	2003	1122	649	23958	2575	2567
CO	3619	1794	1336	37437	4694	9522
CH	784	404	216	7954	643	1998
PS1 (0.0 ∆P) Accident	8623	6177	4466	121050	10941	22713
PS2 (1.7 ∆P)	1141	810	554	16709	1443	9904
Submerged CO/CH	227	12	48	363	23	170
Submerged PS1&2	11441	3416	438	27900	4470	5600
Submerged SRV	144	43	6	352	56	71

Table I-35 - PS Load Adjusted for 0.0 ∆P Normal Operation X-226 - TES

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
PS1 0.0 ∆P Accident	8623	6177	4466	121050	10941	22713
PS1 0.0 ∆P NO	9572	6856	4957	134366	12145	25211
Submerged PS1/2 0.0 ∆P Accident	11441	3416	438	27900	4470	5600
Submerged PS1/2 0.0 ∆P NO	12013	3587	460	29295	4694	5880

Table Notes:

1. Load Condition Adjustment Factors from Section 5.1 and Table 13 use 1.11 for piping and 1.05 for Submerged Structure Loads to adjust from 0.0 Δ PS Accident Condition to 0.0 ΔP NO.

Table I-36 - Reported Event Combination Forces and Moments X-226 - TES

EC	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	4049	3774	2356	96853	158644	28831
16	N+TH+0.0 ΔP PS Accident Condition	20374	10342	5341	153522	82191	38009
21	N+TH+SSE+CO	5120	4047	2695	100928	158725	30872
25	N+TH+SSE+SRV+1.7 ΔP PS	13397	5929	2581	106732	158832	34228

Table Notes:

1. TES considered EC 16 controlling for Primary Membrane Stress Calculation
2. The controlling EC 21 was used for Free Shell Stresses. Based on Attachment A EC 21 would still be controlling as EC 25 stresses do not bound at the location of maximum Free Shell Stress.

Table I-37 - Adjusted Event Combinations Forces and Moments X-226 - TES

EC	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	4049	3774	2356	96853	158644	28831
16 (1 & 3)	N+TH+0.0 ΔP PS NO	21895	11192	5854	168233	83618	40787
21	N+TH+SSE+CO	5120	4047	2695	100928	158725	30872
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ΔP PS NO	22193	11613	6178	192268	160172	46140
EC25 0.0 ΔP NO/EC16 0.0 ΔP Accident Condition		1.09	1.12	1.16	1.25	1.95	1.21
Average Force and Moment Ratios		1.12			1.47		

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.05 [Section 5.1 Table 13].
3. Where: E is External to the Torus and I is Internal to the torus:

   EC 25:= $|DW + TH| + \sqrt{(PSI + PSE)^2 + (SRVI + SRVE)^2 + SSE^2}$

Based on a review of the Table I-37 Adjusted Event Combinations – Forces and Moments EC 25 0.0 ΔP NO is the bounding Event Combination. The increase in Primary Membrane and Membrane plus Bending Stress at the Penetration based on the moment ratio is 1.47 and the bounding adjusted Allowable/ Actual Ratio is 1.10 (Table I-33 Ratio 1.61/1.47). Note: that this ratio matches well with the piping stress increase from 1.7 ΔP PS NO of 26,433 to 0.0 ΔP PS NO of 38,383 psi for EC 25 from Table I-31 and a ratio of 1.45.

X-226 BRANCH LINE REVIEW - TES

1”-W25-152-18

Table I-38 - Reported Stress Results for 1”-W25-152-18 X-226 - TES

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	4435	1.0 S_H = 15,000
1a		P+N+OBE	10054	1.2 S_H = 18,000
1b		P+N+SRV	4953	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	10572	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP	7100	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	10952	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP	12123	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	10761	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.27 Page 8 of 10.

Table I-39 - Individual Load Condition Contributions per EC for 1”-W25-152-18 X-226 - TES

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	4435	1.0 S_H = 15,000	17,100	3.86
1a		P+N+OBE	10054	1.2 S_H = 18,000	20,520	2.04
1b		P+N = 4435 SRV=518	4953	1.2 S_H = 18,000	20,520	4.14
1c	3	P+N+EQ = 10054 SRV = 518	10572	1.8 S_H = 27,000	30,780	2.91
2	16	P+N = 1041 0.0 ΔP External = 1363 Internal = 1302	7100	2.4 S_H = 36,000	41040	5.78
3	21	P+N+EQ = 10054 DBA CO = 898	10952	2.4 S_H = 36,000	41040	3.75
4	25 - 1.7 ΔP NO	P+N+EQ = 10054 1.7 ΔP Internal =1302 External = 767	12123	2.4 S_H = 36,000	41040	3.39
4	25 – 0.0 ΔP (Accident)	P+N+EQ = 10054 0.0 ΔP External = 1363 Internal = 1302	12719	2.4 S_H = 36,000	41040	3.23
4	25 – 0.0 ΔP (NO)	P+N+EQ = 10054 SRV = 0 0.0 ΔP External = 1363 x 1.11 Internal = 1302 x 1.05	12934	2.4 S_H = 36,000	41040	3.17
5	27	P+N+EQ = 10054 SRV = 0 Post CH = 707	10761	2.4 S_H = 36,000	41040	3.81

The X-226 branch line 1”-W25-152-18 Allowable/ Actual Ratio is 2.04.

¾ in VENT LINE

Table I-40 - Reported Stress Results for ¾ in Vent Line X-226 - TES

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	1026	1.0 S_H = 15,000
1a		P+N+OBE	6206	1.2 S_H = 18,000
1b		P+N+SRV	1082	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	6719	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP	1262	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	6776	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP	6808	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	6741	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.27 Page 9 of 10.

Table I-41 - Individual Load Condition Contributions per EC for 3/4 in Vent Line X-226 - TES

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	1026	1.0 S_H = 15,000	17,100	16.67
1a		P+N+OBE	6206	1.2 S_H = 18,000	20,520	3.31
1b		P+N = 1026 SRV=56	1082	1.2 S_H = 18,000	20,520	18.96
1c	3	P+N+EQ = 6663 SRV = 56	6719	1.8 S_H = 27,000	30,780	4.58
2	16	P+N = 1026 0.0 ΔP External = 191 Internal = 45	1262	2.4 S_H = 36,000	41040	32.52
3	21	P+N+EQ = 6663 DBA CO = 113	6776	2.4 S_H = 36,000	41040	6.06
4	25 - 1.7 ΔP	P+N+EQ = 6663 1.7 ΔP External = 100 Internal = 45	6808	2.4 S_H = 36,000	41040	6.03
4	25 – 0.0 ΔP (Accident)	P+N+EQ = 6663 0.0 ΔP External = 191 Internal = 45	6899	2.4 S_H = 36,000	41040	5.65
4	25 – 0.0 ΔP (NO)	P+N+EQ = 6663 0.0 ΔP External = 191 x 1.11 Internal = 45 x 1.05	6922	2.4 S_H = 36,000	41040	5.93
5	27	P+N+EQ = 6663 Post CH = 78	6741	2.4 S_H = 36,000	41040	6.09

The X-226 Allowable/ Actual Ratio for the Vent line is 3.31.

X-226 VALVE REVIEW - TES

Change in EC 25 with from 1.7 ΔP to 0.0 ΔP as a Normal Operating Condition

Table I-42 - EC 25 from 1.7 ΔP to NO 0.0 ΔP Update X-226 - TES

EC 25	1.7 ΔP NO psi	0.0 ΔP NO psi	0.0 ΔP NO/1.7 ΔP NO
X-226 Piping	26433	38383	1.45
W25-152-18	12123	12934	1.07
3/4 Vent	6808	6922	1.02

The maximum stress increase of 45% is at the Torus Penetration X-226.

The piping stress at the valves in the piping system would have a maximum increase of 45% as well. Demonstration of acceptability for valves is to maintain local stress results below Service Level B Allowable Stress Value of $1.2S_H$ as shown in Table I-43.

Table I-43 - EC25 Valve Analysis X-226 - TES

Valve Designation	EC 25 1.7 ΔP psi	EC 25 x 1.45 psi	$1.2 S_H$ psi	Allowable/ 1.45EC25
MOV-58	3045	4415	20520	4.65
VCW-15AN	1269	1840	20520	11.15
MOV-57	1422	2062	20520	9.95
23P-1	2263	3281	20520	6.25
MOV-17	2236	3242	20520	6.33
VCW-15AN	1033	1498	20520	13.70

Table Notes:

1. Reference: 7.4.27 Page 1-2 of 7.

Adequate stress margin exists to demonstrate that all valves will perform their design function using the estimated EC 25 0.0 ΔP PS Normal Operation pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B.

X-226 LOAD CONDITION ECCS SUCTION STRAINER MODIFICATION DE&S

Attachment F discusses details of the load conditions with larger ECCS suction strainers installation on the RHR, CS, HPCI and RCIC suction lines inside the suppression pool (torus). The Mark I Torus Internal loads including; CO, CH, SRV Jet and Bubble, LOCA Jet and Bubble, and Pool Swell (Impact/ Drag, Fallback and Froth) were analyzed for the strainers [7.4.20, 7.4.21, and 7.4.22]. The individual load conditions affecting the strainers will not change for the 0.0 ΔP NO [Attachment F]. Therefore, the analysis in the HPCI penetration X-226 TAP piping analysis for replacement suctions strainer assemblies will be appropriate for TAP X-226 piping analysis for 0.0 ΔP NO [7.4.44].

The TAP was evaluated in accordance with the requirements of ASME, B&PV Code 1977 Edition including Summer 1977 Addenda for pipe stress, flange, strainer core tube loads, pump and valve nozzle load, integral welded attachment stress, penetration load, valve accelerations, pipe support load and branch line evaluation [7.4.44]. All the above evaluations were qualified for the applicable ASME Code requirements. The pipe supports are evaluated for the increase in loads in the individual support calculations [7.4.44 Page 113 of 113].

X-226 PIPE STRESS REVIEW DES

Table 13-1A and Attachment C list the individual load conditions for the maximum external piping stresses principally at Node 70 as summarized in Table I-44 below [7.4.44].

Table I-44 - Reported External Pipe Stress Results X-226 – DE&S

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained	3,178	1.0 S_H = 15,000	17,100	5.38
1a		P+N+OBE	17,458	1.2 S_H = 18,000	20,520	1.18
1b		P+N+SRV	12,473	1.2 S_H = 18,000	20,520	1.65
1c	3	P+N+SRSS (EQ, SRV)	20,859	1.8 S_H = 27,000	30,780	1.48
2	16	P+N+0.0 ΔP	25,935	2.4 S_H = 36,000	41,040	1.58
3	21	P+N+SRSS (EQ, DBA CO)	27,810	2.4 S_H = 36,000	41,040	1.48
4	25	P+N+SRSS (EQ, SRV, 1.7 ΔP)	29,106	2.4 S_H = 36,000	41,040	1.41
5	27	P+N+SRSS (EQ, SRV, Post CH)	22,127	2.4 S_H = 36,000	41,040	1.85

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.44, Attachment C, PISTAR 4.1.2 Stress Combinations Pages 756,778,784,790,802,826,838, and 862.

The load combinations were calculated with the summation of static loads plus the SRSS of the dynamic loads. The maximum external 0.0 ΔP PS load was calculated and EC25 is recalculated in based on the 0.0 ΔP NO condition in Table I-45:

Table I-45 - Maximum External Piping Stress EC25 for 0.0 ∆P NO X-226- DE&S

Stress psi	Load Combination	Value	Reference
A	P+N	3,178	Table I-44 Equation 8
B	SRV	9,295	LC1b-Equation8
C	EQ	15,041	$\sqrt{(LC1c - equation\ 8)^2 - SRV^2}$
D	0.0 ∆P PS Accident	22,757	LC2 - Equation8
E (2)	0.0 ∆P PS NO	25,260	D*1.11
F	EC25 0.0 ∆P NO	34,011	=A+ $(B^2+C^2+(E)^2)^{1/2}$
G	B31.1 Allowable Stress Value psi Reconciled	41,040	Section 2.13 Table 5 2.4 S_H = 2.4*17,100 psi
H	Allowable/EC25 0.0 ∆P NO	1.21	G/F

Table Notes:

1. The Load Condition Adjustment Factor for 0.0 ∆P PS Accident Condition ↓ Download Phase applied to the External PS Load is 1.11 for NO [Section 5.1 Table 13]. In this case it is applied to the Total PS load including the Torus Internal PS Loading. This is conservative because the Torus Internal loads consist of LOCA Bubble & Jet, PS Fallback, SRV Bubble & Jet and Vent Clearing (LOCA Bubble drag load on the strainer). These Torus Internal loads have an Adjustment Factor of 1.0.
2. Note that the loads used in the Table are consistently taken from location of maximum stress, Node 70 of the piping model.
3. SH Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ∆P PS NO Torus Internal and External stress, the total EC 25 stress is 34,011 psi (Allowable/Maximum = 1.21) and EC 25 is the controlling EC. The piping is acceptable for continued service at 0.0 ∆P NO.

Note for the internal piping stress, the maximum Torus Internal Piping stress used would not change for the 0.0 ∆P NO as stated in Section 2.17. Thus, the maximum internal piping stresses for X-226 listed in 7.4.44 Table13-1B satisfying the 0.0 ∆P NO condition.

X-226 PIPE STRESS REVIEW DE&S

Pipe support loads were calculated using PSUP program and combined by DE&S [7.4.44 Section 13.9]. Table I-46 calculated the maximum pipe support loads for EC 25 using the Load Condition Adjustment Factor for 0.0 ∆P PS NO [Section 5.1 Table 13].

Note that the original support designs including those by DE&S generally meet Service Level A for design load conditions in accordance with ASME, Section III, Division I, Subsection NF, 1977 with 1978 Summer Addenda and including NRC Bulletin 79-02 [7.4.44 Section 3.3]. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

Table I-46 - Maximum Pipe Support Loads EC25 for 0.0 ΔP NO X-226- DE&S

Pipe Support	PFSK-2305		PFSK-983	H23-89	PFSK-2248 /SNUB	PFSK-9169	H23-30 SPR	H23-31 SPR	PFSK-2500
Node	65		100	106	110	120	165	255	300
Force lbs	F1	F2	F1	F1	F1	F1	F1	F1	F1
DW	-3207	-266	-1619	0	0	-3251	-4648	-1419	0
SSEI1	7392	5358	3472	3071	2987	1589	35	34	4663
TE1	-572	-2959	803	0	0	-386	-1.6	-6	0
QAB	5491	3441	2410	1126	625	1076	5.1	3	46
PS	5002	-8000	-3379	-1707	5617	2007	5	-2	-14
PSI	2686	1299	935	469	400	367	5	3	398
PS0	5002	-8000	-3379	-1707	5617	2007	5	-2	-14
PS0I	7472	2370	3066	2127	1643	1304	23	13	1105
EC25 1.7 ΔP Accident	15775	14495	6855	3929	6747	6690	4686	1459	4681
EC25 0.0 ΔP Accident	19284	15394	8523	5040	7875	7464	4695	1462	4796
EC25 0.0 ΔP NO	19952	15617	8807	5220	8042	7589	4696	1463	4825
Max Peak	17148	16538	10204	6755	9150	9229	4721	1475	5912
EC25 0.0 ΔP NO/ Max Peak	1.16	0.94	0.86	0.77	0.88	0.82	0.99	0.99	0.82

Pipe Support	PFSK-2242	PFSK-1950	H23-33	H23-34	H23-35	H23-36	H23-37	PFSK-2118	PFSK-1995
Node	305	310	330	350	370	375	400	455	465
Force lbs	F1	F1	F1	F1	F1	F1	F1	F1	F1
DW	0	-4097	-555	-220	-2617	-1716	-2882	-3632	-1881
SSEI1	3408	2721	7464	4957	6942	1101	375	762	2093
TE1	0	320	-1351	251	1429	-223	32	-10	-8
QAB	70	103	101	44	93	24	3	7	35
PS	-114	-61	-54	11	57	-18	2	2	20
PSI	105	178	96	31	73	16	7	12	13
PS0	-114	-61	-54	11	57	-18	2	2	20
PS0I	408	557	461	179	386	57	16	40	94
EC25 1.7 ΔP Accident	3416	6510	9372	4988	8132	3041	3225	3225	3983
EC25 0.0 ΔP Accident	3448	6569	9388	4992	8145	3043	3225	3225	3985
EC25 0.0 ΔP NO	3456	6583	9392	4993	8148	3043	3226	3226	3986
Max Peak	3588	7494	9499	5201	9662	3138	3338	3338	3999
EC25 0.0 ΔP NO/Max Peak	0.96	0.88	0.99	0.96	0.84	0.97	0.97	0.97	1.00

Pipe Support	PFSK-1959		Anchor					
Node	485		490					
Force lbs/ Moment in-lbs	F1	F2	F1	F2	F3	M1	M2	M3
DW	355	-42	4	-86	12	15866	-241	-2182
SSEI1	1421	11618	2086	563	2742	55460	67463	8824
TE1	5	88	50	2	56	229	539	-34
QAB	23	38	16	9	13	899	216	145
PS	-14	4	1	-5	0	-521	22	85
PSI	8	56	14	4	13	337	328	52
PS0	-14	4	1	-5	0	-521	22	85
PSI	63	294	58	23	72	2340	1702	391
EC25 1.7 ΔP Accident	1781	11664	2140	647	2810	71569	67762	11042
EC25 0.0 ΔP Accident	1783	11668	2141	648	2811	71636	67783	11054
EC25 0.0 ΔP NO	1784	11669	2141	648	2811	71650	67788	11056
Max Peak	1793	11676	2154	653	2783	71918	67829	11109
EC25 0.0 ΔP NO/Max Peak	0.99	1.00	0.99	0.99	1.01	1.00	1.00	1.00

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping (PS0I) - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13]
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping (PS0) – Adjustment Factor for Normal Operation is 1.00 for LOCA Bubble, Local Jet, PS Fallback, SRV Bubble and Jet as discussed [Section 5.1 Table 13]
3. Dynamic Loading is combined by SRSS and added absolutely to Static Loading.

   Where: PS0I/PSI is Torus motion inertial loads for pool swell at 0.0 ΔP/1.7 ΔP;

   PS0/PS is pool swell internal structure load at 0.0 ΔP/1.7 ΔP;

   SSEI1 is the design basis earthquake inertia loads;

   TE1 is the thermal expansion of pipe at maximum operating temperature during accident;

   And QAB is SRV load [7.4.44 Section 3 Table 3-2 and Table 3-4].

   EC 25 1.7 ΔP Accident:$= |DW + TE1| + \sqrt{(|PS| + |PSI|)^2 + (QAB)^2 + SSE1^2}$

   EC 25 0.0 ΔP Accident:$= |DW + TE1| + \sqrt{(|PS0| + |PS0I|)^2 + (QAB)^2 + SSE1^2}$

   EC 25 0.0 ΔP NO:$= |DW + TE1| + \sqrt{(|PS0| + |PS0I| * 1.11)^2 + (QAB)^2 + SSE1^2}$
4. EC25 0.0 ΔP PS NO and reported Max Peak loads were compared.
5. Reference: 7.4.44 Attachment F.

X-226 PIPE PENETRATION REVIEW DE&S

The torus shell penetration X-226 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

As discussed in Section 5.3 the change in P_M, P_L, and P_L+P_B for the 0.0 ΔP NO Load Condition at the bounding free shell stress elements (17 & 19) does not affect previously reported controlling ECs. That is, PS ECs 16, 19 & 25 are not controlling the free shell stress results. Therefore, the maximum free shell stresses which occur for EC15 at this penetration location remain valid.

TES Penetration Evaluation results for EC 21 were reported as bounding of the ECs 15, 16, 21 & 25 that were selected for review. In addition, LC17 & LC18 were considered by TES to be controlling for the Penetration Evaluation for the pipe stress results as listed in 7.4.44 Table 13.7-2 after strainer upgrades. The DE&S reported stress results are provided in Table I-47 and the Forces and Moments used for evaluation of the ECs are provided in Table I-48.

Table I-47 - Reported Penetration Stress Results X-226 – DE&S

X-226	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	18667	$1.5S_{MC}$ = 28,900	33,000	1.77
P_L	Torus Shell at Reinforcing Pad	23388	$1.5S_{MC}$ = 28,900	33,000	1.41
P_M	Nozzle	16206	$1.0S_{MC}$ = 19,300	22,000	1.36

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.44 Page 91 and 95 of 113.

Table I-48 - Reported Individual Penetration Loads X-226 – DE&S

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	2652	3046	165	27475	3771	-1455
TH	-2778	2288	-1040	169077	10477	-4963
EQ	10374	4401	2247	255123	15912	14974
SRV	2254	37555	708	170609	4943	13158
PSI (1.7 ΔP)	1101	25405	741	30044	1666	599
PS0I (0.0 ΔP) Accident	4754	50048	1563	101413	7819	3633
PS, PS0 Accident - Submerged	21398	16601	-13329	274774	36882	26141

Table Notes:

1. Reference: 7.4.44 Attachment F Page 10.

Table I-49 - PS Load Adjusted for 0.0 ∆P Normal Operation X-226 – DE&S

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS0I (0.0 ∆P) Accident	4754	50048	1563	101413	7819	3633
PS0I (0.0 ∆P) Normal Operation	5277	55553	1735	112568	8679	4033
Submerged PS, PS0 (0.0 ∆P) Accident	21398	16601	-13329	274774	36882	26141
Submerged PS1/2 (0.0 ∆P) Normal Operation	21398	16601	-13329	274774	36882	26141

Table Notes:

1. Adjustment for Accident Condition 0.0 ∆P PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
2. Adjustment for Accident Condition 0.0 ∆P PS Submerged PS, PS0 loading 1.00 for Normal Operation [Section 5.1 Table 13].

Table I-50 - Adjusted EC – Forces and Moments X-226 – DE&S

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
Max Listed in 7.4.44 Table 13.7-2	Mixed Peaks	28804	89986	15712	540727	62809	37602
25 (1-4)	N+TH+SSE+SRV+0.0 ∆P PS	28836	86796	12706	690748	62760	42582
EC25 0.0 ∆P PS/Max		1.00	0.96	0.81	1.28	1.00	1.13

Table Notes:

1. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11
2. 0.0 ∆P Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.00 as discussed in Section 2.17.
3. Dynamic Loading is combined by SRSS and added absolutely to Static Loading
4. SRSS of the forces and moments for EC25 0.0 ∆P PS and listed maxima respectively and compared. The larger ratio of 1.28 will be used for external force evaluation under EC25 0.0 ∆P PS NO.

Based on a review of the Table I-50- Adjusted EC – Forces and Moments EC 25 is the bounding Event Combination for 0.0 ∆P NO. Therefore, the local membrane stress for the penetration will be reevaluated for Normal Operation with 0.0 ∆P PS. Note that the nozzle stress evaluation used a maximum bounding case considering ECs 15, 16, 21 and 25.

Combining the discontinuity stress and stresses due to external loads for the penetration is shown in Table I-51.

Table I-51 - Local Membrane Stress 0.0 ΔP PS NO X-226 – DE&S

Nozzle intersection stress psi	From External + Internal Load		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	3680	4710	13541	13541	17221	18251
σ_x	3316	4244	3029	3029	6345	7273
$\tau_{x\theta}$	3940	5043	281	281	4221	5324
			Max Principal Stress		18667	20795
Edge of Reinforcement Stress psi	From External Load		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	11895	15226	9162	9162	21057	24388
σ_x	7817	10006	6930	6930	14747	16936
$\tau_{x\theta}$	3932	5033	556	556	4488	5589
			Max Principal Stress		23388	27379
Nozzle stress psi	From External Load		Discontinuity Stress		Sum	
	Original	EC 25 NO	Original	EC 25 NO	Original	EC 25 NO
σ_θ	0	0	13541	13541	13541	13541
σ_x	9575	1078	3029	3029	12604	4107
$\tau_{x\theta}$	2817	3937	281	281	3098	4218
			Max Principal Stress		16206	15152

Table Notes:

1. Reference 7.4.44 Page 90 & 91 of 113.
2. Original Torus Shell Stress from external load was multiplied by 1.28 (conservatively use the maximum increase factor for EC25 0.0 ΔP PS NO forces/moments component from Table I-50). However, the updated Nozzle Stress is calculated EC 25 0.0 PS NO.
3. Discontinuity Stress results were taken from the referenced Penetration Evaluation Section 13.7.
4. The original nozzle stress was calculated for a bounding case from EC's 15, 16, 21 and 25. It remains the controlling case for the evaluation.

Table I-52 - Adjusted Penetration Stress Results X-226 – DE&S

X-226	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	20795	$1.5S_{MC}$ = 28,900	33,000	1.59
P_L	Torus Shell at Reinforcing Pad	27379	$1.5S_{MC}$ = 28,900	33,000	1.21
P_M	Nozzle	15152	$1.0S_{MC}$ = 19,300	22,000	1.45

The Torus Shell and Nozzle Stresses at the Penetration are adequate for continued service at 0.0 ∆P NO.

OTHER COMPONENT REVIEWS X-226 DE&S

DE&S also evaluated the loads for flange, strainer core tube, pump and valve nozzle, IWA, pipe support and branch line [7.4.44]. All the components were shown to be within the acceptable limits with adequate margin. The original calculated allowable/ maximum ratio is divided by the load condition adjustment factor to obtain the allowable/ maximum ratio for 0.0 ∆P NO. The components remain adequate for 0.0 ∆P NO as shown in Table I-53.

Table I-53 - Other Components Loads/Stress for 0.0 ∆P NO X-226- DE&S

	Maximum	Allowable	Allowable/ Maximum	Load Condition Adjustment Factor	Updated Allowable/ Maximum
Flange	939003 in-lbs	1845867 in-lbs	1.966	1.11	1.77
Strainer Core Tube					
Pump 23 P-1	10471 psi	20520 psi	1.960	1.11	1.77
Valve	10186 psi	20520 psi	2.015	1.11	1.82
IWA	9534 psi	41040 psi	4.305	1.11	3.88
Branch line	9603 psi	41040 psi	4.274	1.11	3.85

Table Notes:

1. References 7.4.44 Page 71,72, 79, 81 & 91 of 113
2. Strainer Core Tube loads are not listed in the table. The loads on the strainer are primarily from the Torus Internal loads. A review of the loads was performed, and they do not increase for 0.0 ∆P NO.
3. The maximum Mk I Program Hydrodynamic Load Condition Adjustment Factors of the TAP under 0.0 ∆P PS Normal Operation Loading for External Piping 1.11 per Section 2.17 is conservatively used.

4. Updated allowable/maximum is calculated by the original allowable/maximum ratio divided by the load condition adjustment factor.

Table I-54 - X-226 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ∆P PS NO	1.21
Penetration	Mixed	Mixed	1.36
Flange	Mixed	Mixed	1.77
Strainer Core Tube	Mixed	Mixed	2.03
Pump 23 P-1	Mixed	Mixed	1.77
Valve	Mixed	Mixed	1.81
IWA	Mixed	Mixed	3.88
Branch line	Mixed	Mixed	3.85

X-212 RCIC Turbine Exhaust Piping

The calculation reviewed is Penetration X-212 R2, "Torus Attached Piping Analysis," July 1983 [7.4.28].

X-212 PIPE STRESS REVIEW

Table I-55 - Reported Pipe Stress Results X-212

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	2,410	1.0 S_H = 15,000
1a		P+N+OBE	3,849	1.2 S_H = 18,000
1b		P+N+SRV	3,900	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	13,206	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	19,584	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	32,608	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	25,761	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	17,539	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.28 Page 5 of 9 Rev. 2 and Page 2 of 2 Rev. 0 (Attached to Rev. 2)

Adjusted Pipe Stress Results from X-212

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-56:

Table I-56 - Individual Load Condition Contributions per EC X-212

TES TAP	Event Combination (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	2,410	1.0 S_H = 15,000	17,100	7.10
1a		P+N+OBE	3,849	1.2 S_H = 18,000	20,520	5.33
1b		P+N = 2410 SRV = 1490	3,900	1.2 S_H = 18,000	20,520	5.26
1c	3	P+N+EQ = 11716 EQ =11716 – 2410 = 9306 SRV = 1490	11,835	1.8 S_H = 27,000	30,780	2.60
2	16	P+N = 2410 0.0 ΔP Accident Ext = 5620 x 1.11 Int = 11554 x 1.05	19,584	2.4 S_H = 36,000	41,040	2.09
2	16	P+N = 2410 0.0 ΔP NO Ext = 5620 x 1.11 Int = 11554 x 1.05	20,780	2.4 S_H = 36,000	41,040	1.98
3	21	P+N = 2410 EQ = 9306 DBA CO = 28711	32,592	2.4 S_H = 36,000	41,040	1.26
4	25 - 1.7 ΔP	P+N = 2410 EQ = 9306 1.7 ΔP Ext I = 2491 Int = 11554	19,258	2.4 S_H = 36,000	41,040	2.13
4	25 – 0.0 ΔP (Accident)	P+N = 2410 EQ = 9306 0.0 ΔP Accident Ext = 5620 Int = 11554	21,943	2.4 S_H = 36,000	41,040	1.87
4	25 – 0.0 ΔP (NO)	P+N = 2410 EQ = 9306 0.0 ΔP NO Ext = 5620 x 1.11 Int = 11554 x 1.05	23,003	2.4 S_H = 36,000	41,040	1.78
5	27	P+N+EQ = 11716 SRV = 0 Post CH = 5823	13,388	2.4 S_H = 36,000	41,040	3.07

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination

2. PS is the Load Combination from both the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on 0.0 ∆P from Computer Sequence Number SWLA03Z and SVKJ009T, Sept 1981. This is also confirmed in the section where Internal Structure Submerged loads are calculated. LOCA loads used are based on 0.0 ∆P.
4. SRV is not concurrent with PS/CH/CO due to loss of RPV pressure with DBA events [Section 2.10].
5. Adjustment for Accident Condition 0.0 ∆P PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
6. Adjustment for Accident Condition 0.0 ∆P PS Structure loading 1.05 for Normal Operation [Section 5.1 Table 13].
7. Adjustment for Accident Condition 0.0 ∆P PS Froth and Fallback loading 1.00 for Normal Operation [Section 5.1 Table 13].
8. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.
9. ECs 3, 21, 25 and 27 are calculated by the static stresses added with the SRSS of dynamic stresses:

$$DW + SLP + \sqrt{(EQ)^2 + (DBACO)^2} = 2410 + \sqrt{(9306)^2 + (28{,}711)^2} = 32{,}592\ psi$$

10. EC 25 for 1.7 and 0.0 ∆P Accident Condition and NO are calculated as discussed using the SRSS of dynamic loads.

Based on Table I-56 EC 21 with DBA CO is controlling with a Stress of 32592 psi versus Allowable of 41,040 psi. The controlling stress ratio Allowable/Actual is 1.26.

X-212 PIPE SUPPORT REVIEW

Pipe support loads were tabulated for the PS load cases from Computer Sequence Number HX3TCUB, Jan 1982 (Table I-57) [7.4.28 Page 4 of 42].

Table I-57 - PS load cases at Pipe Support X-212

Support Node Number	Load Condition	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
26	PS		377	184	20623		
45	PS	2341		2291			
142	PS	4326	1239	8836			
146	PS		2904	2105			
148	PS		306	1026			

Based on the results reported by TES the CO/CH support loads were considered negligible and not listed. The PS loads listed above will increase by 11% based on the PS ↓ Download Phase Load Condition Adjustment Factor from 0.0 ∆P Accident Condition to 0.0 ∆P NO Section 5.1.

Note that the original support designs including those by TES generally met Service Level A for design loading conditions. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

Rev. 2 was issue due to a change in support configuration. This change increased support loads at Nodes 142, 146 and 148. The Rev. 0 total design loads were larger than the PS only load reported above. That is the design loads considered the EC combinations not just the PS event. Therefore the 11% increase in PS loading represents a smaller overall increase in support loads.

At Node 25 (PFSK-163), the moments due to torus dynamics were listed and tabulated below in Table I-58 [7.4.28 Page 8 of 11]. The DBACO moments were significantly larger than PS1 and other moments. Thus, even at 0.0 ΔP PS normal operation case, the DBACO RMS would still control by a large margin.

Table I-58 - Moments Reported by TES at Pipe Support PFSK-1963 X-212

Load Case	Mx in-lbs	My in-lbs	Mz in-lbs	SRSS in-lbs
SRV	-9410	310	-9040	13050
PS1	27390	-1010	23930	36390
DBACO	-129700	4290	-119460	176380
SRV+PS2	15110	480	14070	20650
SRV+PC	30190	990	27390	40780

X-212 PIPE PENETRATION REVIEW

The torus shell penetration X-212 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

As discussed in Section 5.3 the change in P_M, P_L, and P_L+P_B for the 0.0 ΔP NO Load Condition at the bounding free shell stress elements (17 & 19) does not affect previously reported controlling ECs. That is, PS ECs 16, 19 & 25 are not controlling the free shell stress results. Therefore, the maximum free shell stresses which occur for EC 15 at this penetration location remain valid.

TES Penetration Evaluation results for EC 21 were reported as bounding of the ECs 15, 16, 21 & 25 that were selected for review. In addition, Rev. 2 of the calculation adjusted the penetration stress results for a change in the support configuration. The TES reported stress results are provided in Table I-59 and the Forces and Moments used for evaluation of the ECs are provided in Table I-60.

Table I-59 - Reported Penetration Stress Results X-212

X-212	Location	Stress psi	Reported psi	Reconciled psi (1)	Allowable/ Actual
P_L	Torus Penetration	27294	$1.5S_{MC}$ = 28,900	33,000	1.21
P_M	Nozzle	15040	$1.0S_{MC}$ = 15,100	17,300	1.15

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.28 Page 4 of 9.
3. The results reported are those that were adjusted in Rev 2.

Table I-60 - Reported Individual Penetration Loads X-212

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
DW	-530	620	-129	6229	120	1530
TH	-62	-1952	-525	62850	-10400	400
EQ	1540	1450	4130	31590	4440	2920
SRV	832	527	371	6220	616	3506
CO	13986	10595	4704	24762	6289	29644
CH	2374	1747	734	4581	1148	4922
PS1 (0.0 ΔP) Accident	3219	2247	1103	6359	1291	9147
PS2 (1.7 ΔP)	835	649	396	2353	334	2620
Submerged PS1/2	9740	1250	1165	49039	121	8100

Table I-61 - PS Forces and Moments Adjusted for 0.0 ΔP NO X-212

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
PS1 (0.0 ΔP) Accident	3219	2247	1103	6359	1291	9147
PS1 (0.0 ΔP) NO	3573	2494	1224	7058	1433	10153
Submerged PS1/2 (0.0 ΔP) Accident	9740	1250	1165	49039	121	8100
Submerged PS1/2 (0.0 ΔP) NO	9740	1250	1165	49039	121	8100

Table Notes:

1. The Torus external 0.0 ΔP PS Accident Load Condition Adjustment Factor for 0.0 ΔP PS NO is 1.11 per Section 5.1.
2. The Torus Internal Loading on the piping considered LOCA Bubble and LOCA Jet. The loads were considered negligible by TES [7.4.28 Page 30 of 42].
3. There are no Torus Internal Impact and Drag loads on the piping [7.4.28 Page 35 of 42].
4. Froth I is the controlling load on the internal piping [7.4.28 Page 35 of 42].
5. The Froth I Load combination adjustment factor is 1.0 from Section 5.1.

Table I-62 - TES Reported EC – Forces and Moments X-212

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	3542	4903	4865	101600	15147	8642
16	N+TH+0.0 ΔP PS	13551	6069	2922	124477	11932	19177
21	N+TH+SSE+CO	14663	13266	6914	109217	18218	31717
25	N+TH+SSE+SRV+1.7 ΔP PS	11311	5019	5085	129723	15026	13501

Table I-63 - Adjusted EC – Forces and Moments X-212

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	3542	4903	4865	101600	15147	8642
16	N+TH+0.0 ΔP PS	13905	4076	3043	125176	11834	20183
21	N+TH+SSE+CO	14663	13266	6914	109217	18218	31717
25	N+TH+SSE+SRV+0.0 ΔP PS	14020	5382	5440	133759	15024	20745
EC25 0.0 ΔP NO/ EC21		0.95	0.41	0.79	1.22	0.82	0.65
Average Force and Moment Ratios		0.72			0.90		

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Froth I Adjustment Factor for Normal Operation is 1.00
3. Where: E is External to the Torus and I is Internal to the torus:

   EC 25:= $|DW + TH| + \sqrt{(PSI + PSE)^2 + (SRVI + SRVE)^2 + SSE^2}$

Based on a review of the Table I-63 - Adjusted Event Combinations – Forces and Moments EC 21 is still the bounding EC for 0.0 ΔP NO. Thus, the penetration is adequate.

BRANCH LINE REVIEW

1.5"-SLP-152-51

Table I-64 - Reported Stress Results for 1.5"-SLP-152-51 - X-212

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	1395	1.0 S_H = 15,000
1a		P+N+OBE	2833	1.2 S_H = 18,000
1b		P+N+SRV	2782	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	8801	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	14983	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	31444	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	18272	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	12990	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.28 Page 9 of 11.

Table I-65 - Individual Load Condition Contributions per EC – X-212

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	1395	1.0 S_H = 15,000	17,100	12.26
1a		P+N+OBE	2833	1.2 S_H = 18,000	20,520	7.24
1b		P+N = 1395 SRV=1387	2782	1.2 S_H = 18,000	20,520	7.38
1c	3	P+N = 1395 EQ = 6019 SRV = 1387	8801	1.8 S_H = 27,000	30,780	3.50
2	16	P+N = 1395 0.0 ∆P PS External = 5575 Internal = 8015	14983	2.4 S_H = 36,000	41040	2.74
3	21	P+N+EQ = 7414 DBA CO = 24030	31444	2.4 S_H = 36,000	41040	1.31
4	25 - 1.7 ∆P	P+N+EQ = 7414 1.7 ∆P PS External = 2843 Internal =8015	18272	2.4 S_H = 36,000	41040	2.24
4	25 – 0.0 ∆P (Accident)	P+N+EQ = 7414 0.0 ∆P PS External = 5575 Internal = 8015	21004	2.4 S_H = 36,000	41040	1.95
4	25 – 0.0 ∆P (NO)	P+N+EQ = 7414 0.0 ∆P PS External = 5575 x 1.11 Internal = 8015 x 1.00	21617	2.4 S_H = 36,000	41040	1.90
5	27	P+N+EQ = 7414 Post CH = 5576	12990	2.4 S_H = 36,000	41040	3.15

Table Notes:

1. The External PS Load Condition includes SRV.
2. The Load Condition Adjustment Factor for the External 0.0 ∆P PS Accident is 1.11 for the 0.0 ∆P PS NO based on the PS ↓ Download Phase.
3. The Load Condition Adjustment Factor for the Internal 0.0 ∆P PS Accident is 1.00 for the 0.0 ∆P PS NO based on the Froth load.
4. The Post CH Load Condition includes SRV
5. Load conditions are absolutely summed which is conservative as dynamic loads can be SRSS'd.

Based on the information provided in the calculation EC 21 is still bounding for this Branch Line.

1"-SLP-152-25

Table I-66 - Reported Stress Results from X-212 for 1"-SLP-152-25

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	534	1.0 S_H = 15,000
1a		P+N+OBE	1214	1.2 S_H = 18,000
1b		P+N+SRV	578	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	1687	1.8 S_H = 27,000
2	16	P+N+0.0 ∆P PS	736	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	2506	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ∆P PS	1766	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	1816	2.4 S_H = 36,000

Table Notes:

1. Reference: 7.4.28 Page 10 of 11.

Table I-67 - Individual Load Condition Contributions per Event Combination

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31 .1	Equation 8	Sustained P+N	534	1.0 S_H = 15,000	17,100	32.02
1a		P+N+OBE	1214	1.2 S_H = 18,000	20,520	16.90
1b		P+N = 534 SRV=44	578	1.2 S_H = 18,000	20,520	35.50
1c	3	P+N = 534 EQ = 1109 SRV = 44	1687	1.8 S_H = 27,000	30,780	18.25
2	16	P+N = 534 0.0 ΔP PS External = 166 Internal = 36	736	2.4 S_H = 36,000	41040	55.76
3	21	P+N+EQ = 1643 DBA CO = 863	2506	2.4 S_H = 36,000	41040	16.37
4	25 - 1.7 ΔP	P+N+EQ = 1643 1.7 ΔP PS External = 87 Internal = 36	1766	2.4 S_H = 36,000	41040	23.24
4	25 – 0.0 ΔP (Accident)	P+N+EQ = 1643 0.0 ΔP PS External = 166 Internal = 36	1845	2.4 S_H = 36,000	41040	22.24
4	25 – 0.0 ΔP (NO)	P+N+EQ = 1643 0.0 ΔP PS External = 166 x 1.11 Internal = 36 x 1.00	1865	2.4 S_H = 36,000	41040	22.01
5	27	P+N+EQ = 1643 Post CH = 173	1816	2.4 S_H = 36,000	41040	22.60

Table Notes:

1. See Notes for Table I-65.

Based on the information provided in the calculation EC 21 is still bounding for this Branch Line.

X-212 VALVE REVIEW

Change in EC 25 with the pipes from 1.7 ΔP to 0.0 ΔP as a Normal Operating Condition is shown in Table I-68.

Table I-68 - EC 25 from 1.7 ΔP to NO 0.0 ΔP Update X-212

EC 25	1.7 ΔP NO psi	0.0 ΔP NO psi	0.0 ΔP /1.7 ΔP NO
X-212 Piping	19258	23154	1.20
1.5"-SLP-152-51	18272	21617	1.18
1"-SLP-152-25	1766	1865	1.06

Table Notes:

1. The X-212 piping EC was conservatively combined for 1.7 ΔP NO reported by TES

The maximum increase of 20% as anticipated is at the Torus Penetration X-212.

The piping stress at the valves in the piping system would be anticipated to have a maximum increase of 20% as well. Demonstration of acceptability for valves is to maintain local stress results below Service Level B Allowable Stress Value of $1.2S_H$ as shown in Table I-69. The maximum stresses for the valves were then compared and summarized in Table I-70.

Table I-69 - VGW-15AN and VCW-15AN EC25 Analysis X-212

Valve Designation	EC 25 1.7 ΔP psi	EC 25 x 1.20 psi	1.2 S_H psi	Allowable/1.20EC25
VGW-15AN	10047	12056	20520	1.70
VCW-15AN	9498	11398	20520	1.80
VCW-15AN	6725	8070	20520	2.54

Table Notes:

1. Reference: 7.4.28 Page 1 of 4.

Table I-70 - VGW-15AN and VCW-15AN Maximum Stress Analysis X-212

Valve Designation	EC of Maximum Stress	Stress psi	1.2 S_H psi	Allowable/Maximum
VGW-15AN	21	15925	20520	1.29
VCW-15AN	21	15320	20520	1.34
VCW-15AN	21	16217	20520	1.27

Table Notes:

1. Reference: 7.4.28 Page 1 of 4.

Adequate margin exists to demonstrate that all valves will perform their design function using the estimated EC 25 0.0 ΔP PS Normal Operation pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B.

Table I-71 - X-212 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	21	DBA CO	1.26
Support	21	DBA CO	-
Penetration	21	DBA CO	1.15
Branch Line	21	DBA CO	1.31
Valves	21	DBA CO	1.27

X-224 RCIC Pump Suction Piping

The calculation reviewed is Penetration X-224 R1, "Torus Attached Piping Analysis," July 1983 [7.4.29]. There is no calculation available for the addition of the new suction strainer in 1998. The new ECCS and RCICI Suction Strainers are discussed in Section 2.17.

X-224 PIPE STRESS REVIEW

Table I-72 - Reported Pipe Stress Results X-224

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	3,837	1.0 S_H = 15,000
1a		P+N+OBE	10,530	1.2 S_H = 18,000
1b		P+N+SRV	9,312	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	16,005	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	15,335	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	14,281	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	25,146	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	16,792	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.29 Page 2 of 2 and 7 of 22

Adjusted Pipe Stress Results from X-224

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-73.

Table I-73 - Individual Load Condition Contributions per Event Combination X-224

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	3,837	1.0 S_H = 15,000	17,100	4.46
1a		P+N+OBE	10,530	1.2 S_H = 18,000	20,520	1.95
1b		P+N = 3837 SRV=5475	9,312	1.2 S_H = 18,000	20,520	2.20
1c	3	P+N = 3837 EQ = 6693 SRV = 5475	12,484	1.8 S_H = 27,000	30,780	2.47
2	16	P+N = 3837 0.0 ∆P External = 3808 Internal = 7690	15,335	2.4 S_H = 36,000	41,040	2.68
3	21	P+N+EQ = 10530 DBA CO = 3751	11,509	2.4 S_H = 36,000	41,040	3.57
4	25 - 1.7 ∆P	P+N+EQ = 10530 1.7 ∆P External = 6926 Internal = 7690	19,913	2.4 S_H = 36,000	41,040	2.06
4	25 – 0.0 ∆P (Accident)	P+N+EQ = 10530 0.0 ∆P External = 3808 Internal = 7690	17,141	2.4 S_H = 36,000	41,040	2.39
4	25 – 0.0 ∆P (NO)	P+N+EQ = 10530 0.0 ∆P External = 3808 x 1.11 Internal = 7690 x 1.05	17,841	2.4 S_H = 36,000	41,040	2.30
5	27	P+N+EQ = 10530 SRV+Post CH = 6262	13003	2.4 S_H = 36,000	41,040	3.16

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. The PS is the Load Combination is from both the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on 0.0 ∆P.
4. This is also confirmed in the section where Internal Structure Submerged loads are calculated. LOCA loads used are based on 0.0 ∆P.

5. SRV is not concurrent with CH/CO due to loss of RPV pressure with DBA events [Section 2.10].
6. The PS 1 and PS 2 cases include the SRV load condition [7.4.29 Page 10 of 22]. Note that the PS 2 Load Condition which is the 1.7 ΔP NO is significantly larger than the 0.0 ΔP NO Load Condition.
7. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
8. Adjustment for Accident Condition 0.0 ΔP PS Structure loading 1.05 for Normal Operation [Section 5.1 Table 13].
9. Adjustment for Accident Condition 0.0 ΔP PS Froth and Fallback loading 1.00 for Normal Operation [Section 5.1 Table 13].
10. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.
11. The EC Load Conditions 3, 21, 25 and 27 are combined by absolute summation of the Static Loads and SRSS of the Dynamic Loads.

Based on Table I-73 EC 25 for 0.0 PS NO is controlling with a Stress of 17841 psi versus Allowable of 41,040 psi. The controlling stress ratio Allowable/Actual is 2.30. Note that with the new configuration the 1.7 PS NO case will no longer be valid.

X-224 PIPE SUPPORT REVIEW

Pipe support loads and displacements were tabulated for the PS load cases from Computer Sequence Number HX3E6F, March 1983 (Table I-74) [7.4.29 Page 4 of 37].

Table I-74 - PS load cases at Pipe Support

Support Node Number	Load Condition	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
177	PS		142				
183	PS		428				

Based on the results reported by TES the CO/CH support loads were considered negligible and not listed. The PS loads listed above will increase by a maximum of 11% based on the PS ↓ Download Phase Load Condition Adjustment Factor from 0.0 ΔP Accident Condition to 0.0 ΔP NO Section 5.1.

Note that the original support designs including those by TES generally met Service Level A for design loading conditions. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

X-224 PIPE PENETRATION REVIEW

The torus shell penetration X-224 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

As discussed in Section 5.3 the change in P_M, P_L, and P_L+P_B for the 0.0 ΔP NO Load Condition at the bounding free shell stress elements (17 & 19) does not affect previously reported controlling ECs. That is, PS ECs 16, 19 & 25 are not controlling the free shell stress results. Therefore, the maximum free shell stresses which occur for EC 21 at this penetration location remain valid.

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Therefore, only EC 21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21 is bounding still applies (Table I-75 to Table I-79).

Table I-75 - Reported Penetration Stress Results X-224

X-224	Location	Stress psi	Reported psi	Reconciled psi (1)	Allowable/ Actual
P_L	Torus Penetration	16028	$1.5S_{MC}$ = 28,900	33,000	2.06
P_M	Nozzle	13877	$1.0S_{MC}$ = 15,100	17,300	1.25

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.29 Page 25 and 28 of 37.

Table I-76 - Reported Individual Penetration Loads X-224

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
DW	572	-400	-1	-420	-540	-7896
TH	-1228	662	139	271	3546	66108
EQ	73	78	1558	71564	62756	1104
SRV	2222	1260	1019	26237	9636	10674
CO	3914	2299	623	16218	8690	16861
CH	1017	592	188	3943	2343	2676
PS1 (0.0 ΔP) Accident	1501	770	296	9641	9017	14695
PS2 (1.7 ΔP)	332	177	90	3498	1737	6563
Submerged CO/CH	74	60	26	105	463	460
Submerged PS1/2	590	1058	6	2110	975	6900

Table I-77 - PS Load Adjusted for 0.0 ΔP Normal Operation X-224

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
PS1 (0.0 ΔP) Accident	1501	770	296	9641	9017	14695
PS1 (0.0 ΔP) NO	1666	855	329	10702	10009	16311
Submerged PS1/2 (0.0 ΔP) Accident	590	1058	6	2110	975	6900
Submerged PS1/2 (0.0 ΔP) NO	620	1111	6	2216	1024	7245

Table Notes:

1. The Torus external 0.0 ΔP PS Accident Load Condition Adjustment Factor for 0.0 ΔP PS NO is 1.11 per Section 5.1 Table 13.
2. The Torus Internal PS Loading on the piping considered LOCA Bubble, LOCA Jet. Impact and Drag and Fallback. [7.4.28 Page 30 of 42]. Based on review the LOCA loads are for the 0.0 ΔP PS Accident Condition.
3. The Fallback, LOCA Bubble and Jet Load Combination Adjustment Factors are 1.0 from Section 5.1 Table 13. The PS Impact and Drag Factor is 1.05. Therefore use 1.05 on the Torus Internal PS Load Conditions.

Table I-78 - Reported EC Forces and Moments X-224

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	3132	1683	2012	76478	66559	69392
16	N+TH+0.0 ΔP PS	2747	2090	440	11900	12998	79807
21	N+TH+SSE+CO	4646	2622	1826	73551	66578	75568
25	N+TH+SSE+SRV+1.7 ΔP PS	3063	2028	2002	76577	66555	75428

Table I-79 - Adjusted EC Forces and Moments X-224

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
15	N+TH+SSE+SRV+CH	3132	1683	2012	76478	66559	69392
16 (1 & 2)	N+TH+0.0 ΔP PS	2942	2228	473	13066	14039	81768
21	N+TH+SSE+CO	4646	2622	1826	73551	66578	75568
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ΔP PS	3845	2598	2030	77458	67449	84098
	EC25/EC21	.82	.99	1.11	1.05	1.01	1.11
	Average	0.97			1.06		

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.05 [Section 5.1 Table 13].
3. Where: E is External to the Torus and I is Internal to the torus:

   EC 25:= $|DW + TH| + \sqrt{(PSI + PSE)^2 + (SRVI + SRVE)^2 + SSE^2}$

Based on a review of the Table I-79 - Adjusted Event Combinations – Forces and Moments from EC 21 are no longer bounding. However, EC 25 for 0.0 ΔP NO is approximately 6% higher in magnitude. Based on the adjusted results in Table I-80 below the penetration is adequate.

Table I-80 - Adjusted Penetration Stress Results X-224

X-224	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Penetration	16990	$1.5S_{MC}$ = 28,900	33,000	1.94
P_M	Nozzle	14710	$1.0S_{MC}$ = 15,100	17,300	1.18

Table Notes:

1. TES Reported Penetration Stress Results from Table I-79 have been adjusted by 1.06.

X-224 BRANCH LINE REVIEW

Table I-81 - Reported Stress Results from X-224

Branch Lines	TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled (2) psi	Allowable/ Actual
2"-W22-152-11	LC3	21	P+N+EQ+DBA CO	4238	2.4 SH = 36,000	41040	9.68
3/4" Drain - Node 138	LC3	21	P+N+EQ+DBA CO	6692	2.4 SH = 36,000	41040	6.13
3/4" Vent	LC4	25	P+N+EQ+SRV+ 1.7 ΔP	3749	2.4 SH = 36,000	41040	10.94
3/4" Drain - Node 158	LC4	25	P+N+EQ+SRV+ 1.7 ΔP	3953	2.4 SH = 36,000	41040	10.38
1” W20-302-110			Not Analyzed by TES				

Table Notes:

1. Reference: 7.4.29 Page 16-19 of 22 Page 9 of 9
2. Reconciled allowable stress is from Section 2.13 Table 11.

Based on the above information for the Branch Lines the controlling stress ratio is 6.13 and increasing the 0.0 ΔP PS accident condition for NO will affect the results by less than 11%. Therefore, the Branch Lines are adequate. Branch line 1” W20-302-110 was not reported during the MK I Program. Based on the large ratio to allowable demonstrated at other locations this branch line is not of concern.

X-224 VALVE REVIEW

The stresses for valves/pump are shown in Table I-82. Note that the controlling EC 25 for the Pipe Stress was reduced for 0.0 ΔP NO. Therefore, use the TES reported valve stress results directly.

Table I-82 - Stresses in Valves/Pump X-224

Valve/Pump Designation	Maximum Stress psi	1.2 S_H psi	Allowable/ Maximum Stress
MOV-41	6925 (2)	20520	2.96
VCW-15AN	2648	20520	7.75
MOV-39	3389	20520	6.05
VGW-15AN	1881	20520	10.91
13P-1	2890	20520	7.10
VCW-15AN	244	20520	84.10
MOV-18	72	20520	285.00
MOV-36	207	20520	99.13
AOV-71A	33	20520	621.82
MOV-21A	36	20520	570.00

Table Notes:

1. Reference: 7.4.29 Page 1-3 of 16.
2. Maximum stress is EC 25 for MOV-41.
3. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Adequate stress margin exists to demonstrate that pumps and valves will perform their design function for 0.0 ΔP PS NO.

Table I-83 - X-224 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP NO	1.80
Penetration	25	0.0 ΔP NO	1.18
Branch Lines	21	DBA CO	6.13
Valves	25	0.0 ΔP NO	2.96

X-228 Condensate Drain Line Piping

The calculation reviewed is Penetration X-228 R0, "Torus Attached Piping Analysis," July 1983 [7.4.30].

X-228 PIPE STRESS REVIEW

Table I-84 - Reported Pipe Stress Results from X-228

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	4,192	1.0 S_H = 15,000
1	3	P+N+EQ+SRV	17,745	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	16,987	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	25,456	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	29,447	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	20,132	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.30

Adjusted Pipe Stress Results from X-228

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-85:

Table I-85 - Individual Load Condition Contributions per EC X-228

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	4,192	1.0 SH = 15,000	17,100	4.08
1	3	P+N+EQ+SRV	17,745	1.8 SH = 27,000	30,780	1.73
2	16	P+N = 4192 0.0 ΔP External= 2132 Internal = 10663	16,987	2.4 SH = 36,000	41,040	2.42
3	21	P+N+EQ +DBA CO	25,456	2.4 SH = 36,000	41,040	1.61
4	25 - 1.7 ΔP NO	P+N+EQ+SRV = 17745 1.7 ΔP External= 1039 Internal = 10663	29,447	2.4 SH = 36,000	41,040	1.39
4	25 – 0.0 ΔP (Accident)	P+N+EQ+SRV = 17745 0.0 ΔP External = 2132 Internal = 10663	30,540	2.4 SH = 36,000	41,040	1.34
4	25 – 0.0 ΔP (NO)	P+N+EQ+SRV = 17745 0.0 ΔP External = 2132 x 1.11 Internal = 10663 x 1.0	30,775	2.4 SH = 36,000	41,040	1.33
5	27	P+N+EQ+SRV=17745 Post CH = 2387	20,132	2.4 S_H = 36,000	41,040	2.04

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. The PS is the Load Combination from both the piping external to the torus and internal to the torus.
3. Based on the reported results the loads internal to the torus were calculated based on 0.0 ΔP.
4. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment.

5. Internal PS Loads are given in 7.4.30 Page 4 of 61. Note that the Torus Internal Loads except for Froth (Froth calculation follows on Page 50) were considered negligible on Page 49 of 61.
6. The Adjustment for 0.0 ΔP PS Accident Condition Froth and Fallback to obtain the Structural Loading for NO is 1.00 [Section 5.1 Table 13].
7. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 for 0.0 ΔP NO the total EC 25 stress is 30,775 psi with an Allowable Stress Value of 41040 psi. The stress increase for EC 25 is 1,328 psi (4.5%).

X-228 PIPE SUPPORT REVIEW

Pipe support loads were tabulated for the PS load cases from Computer Sequence Number HX3UB8F, December 1982 (Table I-86) [7.4.30 Page 5 of 61].

Table I-86 - PS load cases at Pipe Support X-228

Support Node Number	Load Condition	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz in-lbs
10	PS	790	663				

Based on the results reported by TES the CO/CH support loads were considered negligible and not listed. The PS loads listed above will increase by a maximum of 11% based on the PS ↓ Download Phase Load Condition Adjustment Factor from 0.0 ΔP Accident Condition to 0.0 ΔP NO Section 5.1.

Note that the original support designs including those by TES generally met Service Level A for design loading conditions. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

The analysis results for the Torus Internal support structural members are given in Table I-87:

Table I-87 - Reported Torus Internal Pipe Support Loads X-228

EC	Internal Support	Results	Allowable	Reconciled Allowable	Reference
25	Torus Shell	P_L = 17501 psi	1.5 S_{MC} = 28,900 psi	33,000 psi	[7.4.30 Page 37 of 61]
16	Penetration	$P_L + P_B$ = 23704 psi	1.5 S_{MC} = 28,900 psi	33,000 psi	[7.4.30 Page 40 of 61]
16	Weld	T_{WELD} = 16,373 psi	0.3 S_U = 18,000 psi	21,000 psi	[7.4.30 Page 41 of 61]
16	U-Bolt	Interaction = 0.47	Interaction = 1.0	N/A	[7.4.30 Page 42 of 61]

Table Notes:

1. Allowable Stress Values are taken from Section 2.13
2. Allowable Weld Stress Values are taken from Section 2.14.

Table I-88 - Torus Force and Moment Results for Internal Pipe Support Shell and Penetration Evaluation X-228

EC	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz In-lbs
16 0.0 ΔP Accident	N+TH+0.0 ΔP PS	22980	26188	81	5064	1283	22357
16 0.0 ΔP NO	N+TH+0.0 ΔP PS	23165	21205	84	5199	1419	23343
25 1.7 ΔP NO	N+TH+SSE+SRV +1.7 ΔP PS	22688	27933	2539	128640	4613	20029
25 0.0 ΔP NO	N+TH+SSE+SRV +0.0 ΔP PS	23293	22267	2492	126659	4127	23756
EC 16	NO/ Accident Condition	1.01	0.81	1.04	1.03	1.11	1.04
EC 16	Average = 1.01	0.95			1.06		
EC 25	NO/ Accident Condition	1.03	0.80	0.98	.98	0.90	1.19
EC 25	Average = 0.98	0.94			1.02		

Table Notes:

1. The Force and Moment results are taken from X-228 Table I-92 and Table I-93 below.

Based on Table I-88 above, the average increase for the adjusted 0.0 ΔP NO ECs is approximately 1.0. Therefore, the reported Torus Shell and Penetration Primary Local and Bending stresses due to the Torus Internal Support remain the same. Note that the adjusted EC results were combined using signed static and SRSS of the dynamic loading while the TES Reported EC results were combined by absolute summation.

Only the PS Froth Load Condition was analyzed for the Torus Internal Support Loading. TES determined that the other PS loads were negligible [7.4.30 Page 49 of 61]. The Load Condition Adjustment Factor in Section 5.1 for the 0.0 ΔP PS Froth Accident Condition to obtain the 0.0 ΔP PS NO Load Condition is 1.00.

The TES reported results for the Torus Internal Support will not change for 0.0 ΔP NO. Therefore, the support is acceptable for continued service at 0.0 ΔP NO.

X-228 PIPE PENETRATION REVIEW

The torus shell penetration X-228 was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Therefore, only EC 21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21 is bounding still applies (Table I-89 to Table I-93).

Table I-89 - Reported Penetration Stress Results X-228

X-228	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Penetration	22294	$1.5S_{MC}$ = 28,900	33,000	1.48
P_M	Nozzle	13481	$1.0S_{MC}$ = 15,100	17,300	1.28

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.30 Page 24 and 30 of 61.

Table I-90 - Reported Individual Penetration Loads X-228

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz In-lbs
DW	-400	2659	0	0	0	1189
TH	-20476	-19676	51	3840	50	10000
EQ	160	500	2440	122800	3820	820
SRV	760	3126	38	1707	398	3087
CO	5880	7043	255	5713	3465	24166
CH	1025	1556	49	1000	697	3935
PS1 (0.0 ΔP) Accident	1684	3048	30	1224	1233	8968
PS2 (1.7 ΔP)	472	1167	10	293	345	2733
Submerged PS1/2	420	805	0	0	0	2200

Table I-91 - PS Load Adjusted for 0.0 ΔP NO X-228

Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz In-lbs
PS1 (0.0 ΔP) Accident	1684	3048	30	1224	1233	8968
PS1 (0.0 ΔP) Normal Operation	1869	3383	33	1359	1369	9954
Submerged PS1/2 (0.0 ΔP) Accident	420	805	0	0	0	2200
Submerged PS1/2 (0.0 ΔP) NO	420	805	0	0	0	2200

Table Notes:

1. The Torus external 0.0 ΔP PS Accident Load Condition Adjustment Factor for 0.0 ΔP PS NO is 1.11 per Section 5.1 Table 13.

2. The Torus Internal PS Loading on the piping considered LOCA Bubble, LOCA Jet. Impact and Drag and Froth I & II. [7.4.30 Page 49 of 61]. Based on review the LOCA loads are for the 0.0 ΔP PS Accident Condition.
3. The Froth I & II are the only Torus Internal loads applied as the LOCA Bubble and Jet Load and PS Impact and Drag were negligible [7.4.30 Page 49 of 61]. The Froth I & II Load Combination Adjustment Factor is1.0 from Section 5.1 Table 13.

Table I-92 - Reported EC Forces and Moments X-228

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz In-lbs
15	N+TH+SSE+SRV+CH	22821	27517	2578	129347	4965	19031
16	N+TH+0.0 ΔP PS	22980	26188	81	5064	1283	22357
21	N+TH+SSE+CO	26916	29878	2746	132353	7335	36175
25	N+TH+SSE+SRV+1.7 ΔP PS	22688	27933	2539	128640	4613	20029

Table I-93 - Adjusted EC Forces and Moments X-228

Event Combination	Load Conditions	Fx lbs	Fy lbs	Fz lbs	Mx in-lbs	My in-lbs	Mz In-lbs
15	N+TH+SSE+SRV+CH	22821	27517	2578	129347	4965	19031
16	N+TH+0.0 ΔP PS	23165	21205	84	5199	1419	23343
21	N+TH+SSE+CO	26916	29878	2746	132353	7335	36175
25	N+TH+SSE+SRV+0.0 ΔP PS	23293	22267	2492	126659	4127	23756
EC25/EC21		0.87	0.75	0.91	0.96	0.56	0.66

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for NO is 1.11 [Section 5.1 Table 13].
2. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Froth I & II Adjustment Factor for NO is 1.00 [Section 5.1 Table 13].
3. Internal Submerged Loading is combined by SRSS and added absolutely to External Loading
4. Where: E is External to the Torus and I is Internal to the torus:

   EC 25:= $|DW + TH| + \sqrt{(PSI + PSE)^2 + (SRVI + SRVE)^2 + SSE^2}$

Based on a review of the Table I-93 Adjusted EC Forces and Moments EC 21 is still the bounding Event Combination for 0.0 ΔP NO. Thus, the penetration is acceptable for continued operation.

X-228 BRANCH LINE REVIEW

No Brach line was analyzed in 7.4.30.

X-228 VALVE REVIEW

The stresses for valves/pump are shown in Table I-94.

Table I-94 - Pipe Stress at Valves & Pumps X-228

Valve/Pump Designation	Maximum Stress psi	1.2 S_H psi	Allowable/ Maximum Stress
VGW-15A	9062 (EC27)	20520	2.26
VGW-15A	9032 *1.04 = 9393 (EC25)	20520	2.18

Table Notes:

1. Reference: 7.4.30 Page 1 of 3.
2. Maximum stress is EC 27 for the valve.
3. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Adequate stress margin exists to demonstrate that all valves will perform their design function even using the estimated EC 25 0.0 ΔP PS Normal Operation pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B. Note that the Table I-85 pipe stress for bounding EC 25 increased 4% from 29,447 to 30,775 psi.

Table I-95 – X-228 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP NO	1.33
Penetration	21	DBA CO	1.28
Valves	25	0.0 ΔP NO	2.18

X-205 Reactor Building Normal Vent Piping

The calculation reviewed is Penetration X-205 R1, "Torus Attached Piping Analysis," August 1983 [7.4.31]. This calculation was revised as R2 based on EC 619886 Markup of X-205 [7.4.42].

The revision 2 is to address the material and weight discrepancy related to line 20"-N-152A-20, 20"-N-151A-22, and 30"-N-151A-21 for Torus Penetration X-205 found by CR-JAF-2016-05223: JAF-SPECMISC-00334 specifies Schedule 10 piping while the fabrication drawings called out Standard Schedule piping [7.4.42 Page 7 of 97].

X-205 PIPE STRESS REVIEW

Revision 2 of the calculation X-205 recalculated the governing Mark I load combinations using the correct piping material and schedule [7.4.42]. The Mark I load combinations added the static loads to the SRSS of the dynamic loads as show in section 7.5 of the Revision 2 calculation. The results are shown in Table I-96.

Table I-96 - Reported Pipe Stress Results from X-205

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	P+DW	1,685	1.0 S_H = 15,000
1a		P+DW+OBE	17,292	1.2 S_H = 18,000
1b		P+DW+SRV	2,758	1.2 S_H = 18,000
1c	3	P+DW+SSE + SRV	17,355	1.8 S_H = 27,000
3	21	P+N+EQ+DBA CO	18,530	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+0.0 ΔP PS	17,685	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+ CH	17,500	2.4 S_H = 36,000

Table Notes:

1. The Pool Swell Stresses used in the pipe stress load combinations are the maximum/minimum stresses from both Pool Swell Load Cases (PS1 and PS2). Therefore, P + DW + PS1 is bounded by P + DW + SSE + PS+ SRV
2. Reference: 7.4.42 Page 56 of 97.

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-97:

Table I-97 - Individual Load Condition Contributions per Event Combination X-205

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	1,685	1.0 SH = 15,000	17,100	10.15
1a		P+N+OBE OBE = 15,607	17,292	1.2 SH = 27,000	20,520	1.19
1b		P+N+SRV SRV=1073	2,758	1.2 SH = 27,000	20,520	7.44

1c	3	P+N+SSE + SRV SSE=15633	17,355	1.8 SH = 27,000	30,780	1.77
3	21	P+N+OBE +DBA CO	18,530	2.4 SH = 36,000	41,040	2.21
4	25 – Max (0.0 ΔP, 1.7 ΔP (Accident)	P+N+SSE+ SRV+0.0 ΔP PS PS=3234	17,685	2.4 SH = 36,000	41,040	2.32
4	25 – 0.0 ΔP (NO)	P+N+SSE+ SRV + 0.0 ΔP PS NO 0.0 ΔP PS NO = 3234 X 1.11	17,761	2.4 SH = 36,000	41,040	2.31
5	27	P+N+SSE+ SRV+ CH	17,500	2.4 S_H = 36,000	41,040	2.35

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. No Torus Internal Load contribution.
3. SRV is not concurrent with CH/CO due to loss of RPV pressure with DBA events [Section 2.10].
4. SRSS combination of the dynamic loads was used.

   EC 25:= $|P + DW| + \sqrt{PS^2 + SRV^2 + SSE^2}$
5. The Pool Swell Stresses used in the pipe stress load combinations are the maximum/minimum stresses from both Pool Swell Load Cases (PS1 and PS2). Therefore, P + DW + PS1 is bounded by P + DW + SSE + PS+ SRV
6. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment.
7. S_H Value is increased per Section 2.13 Table 5 from 15,000 to 17,100 psi.
8. Reference: 7.4.42 Page 56 of 97.

Based on the adjustment to EC 25 to adjust for 0.0 ΔP NO, EC 21 is still the controlling (18,530 psi) for the DBA cases. However, the OBE case has the lowest Allowable/Actual Ratio = 1.19.

X-205 PIPE SUPPORT REVIEW

Pipe support load summaries post-strainer installations were provided in 7.4.42. The loads conservatively used maximum/ minimum loads from both the Pool Swell Load Cases (PS1 and PS2) and all the SRV Load Cases (SRV1, SRV2, and SRV3) [7.4.42 Page 95 of 97]. The pipe supports (BFSK-519, BFSK-696, BFSK-711 and modified BFSK-982 (Snubber & Strut)) were evaluated and considered structurally adequate in calculation JAF-CALC-17-00085 based on the conservative loading condition [7.4.49].

Table I-98 - Support Evaluation for 0.0 ∆P NO X-205

BFSK	696		982	711	519	715					
Load	**Fx lbs**	**Fy lbs**	**Fx lbs**	**Fy lbs**	**Fy lbs**	**Fx lbs**	**Fy lbs**	**Fz lbs**	**Mx in-lbs**	**My in-lbs**	**Mz in-lbs**
DW	-3	-79	-6	-5855	-853	-3	-3769	71	-10435	-266	-383
	-3	-79	-6	-5855	-853	-3	-3769	71	-10435	-266	-383
TH	0	221	0	342	0	138	42	0	17084	7754	20370
	-138	0	-195	0	-13	0	0	-116	0	0	0
OBE	1997	4519	7852	3859	0	951	703	1034	143418	69178	133969
	-1997	-4519	-7852	-3859	0	-951	-703	-1034	-143418	-69178	-133969
SSE	1723	4282	6546	3402	0	865	967	1098	150476	57543	124216
	-1723	-4282	-6546	-3402	0	-865	-967	-1098	-150476	-57543	-124216
PS	358	916	850	817	0	264	740	542	65089	6788	31548
	-326	-884	-722	-763	0	-261	-736	-537	-65764	-6361	-31283
SRV	157	1007	737	312	0	133	131	233	25605	3548	15465
	-179	-911	-771	-286	0	-148	-167	-198	-28313	-3365	-17316
EC25	2032	4862	7926	-1556	-853	1131	-2502	1317	172586	77089	158487
	-2172	-4773	-8124	-9799	-866	-1000	-4996	-1283	-177077	-69817	-139041
EC21	2065	5076	7984	-1554	-853	1284	2501	1551	195116	77302	174540
	-2213	-4934	-8221	-9851	-866	-1145	-4983	-1484	-202943	-69986	-154255
PS x 1.11	397	1017	944	907	0	293	821	602	72249	7535	35018
	-362	-981	-801	-847	0	-290	-817	-596	-72998	-7061	-34724
EC25 0.0 ∆P PS NO	2039	4882	7937	-1537	-853	1139	-2451	1345	175523	77166	159318
	-2178	-4792	-8131	-9816	-866	-1008	-5046	-1310	-180062	-69885	-139858
EC25/EC21	0.99	0.96	0.99	0.99	1.00	0.89	-0.98	0.87	0.90	1.00	0.91
	0.98	0.97	0.99	1.00	1.00	0.88	1.01	0.88	0.89	1.00	0.91

Table Notes:

1. Reference: [7.4.42 Pages 86 - 89 of 97]
2. Adjustment for Accident Condition 0.0 ∆P PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13. This largest adjustment factor was conservatively used for EC 25 adjustment.

The 0.0 ∆P PS ↓Download Accident Condition Load Condition was adjusted using the Load Condition Adjustment Factor of 1.11 for 0.0 ∆P PS NO [Section 5.1 Table 13]. The results for EC 25 0.0 ∆P NO are less than or equal to EC 21. Therefore, the support loads previously provided remain bounding. The supports are adequate for continued service at 0.0 ∆P PS NO [7.4.42 Page 75 of 97].

X-205 PIPE PENETRATION REVIEW

The torus shell penetration X-205 was evaluated in Revision 2 based on the external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18]. The free shell stress results were selected from the nearest element to the penetration. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs.

Table I-99 - Reported Penetration Stress Results X-205

X-205	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	13864	$1.5S_{MC}$ = 28,900	33,000	2.38
P_L	Torus Shell at Nozzle Pad	12224	$1.5S_{MC}$ = 28,900	33,000	2.70
P_M	Nozzle	12958	1.0 S_{MC} = 19,300	22,000	1.70

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.42 Pages 68, 78 & 84 of 97
3. Individual load combinations are taken from Attachment BB for Beam 39, Node 161 [7.4.31 Page BB250 & 251 of BB331.

Table I-100 - Reported Penetration Loads X-205

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-371	-3	13	711	1271	647
	-371	-3	13	711	1271	647
THDES	0	341	242	0	0	4416
	-674	0	0	-26625	-10643	0
TH	0	172	140	0	0	2733
	-371	0	0	-12495	-5718	0
OBE	3225	5308	5054	197624	23545	34196
	-3225	-5308	-5054	-197624	-23545	-34196
SSE	2663	4430	4238	219582	23113	29834
	-2663	-4430	-4238	-219582	-23113	-29834
PS	1772	950	1093	7701	3451	4937
	-2515	-1006	-1118	-7970	-3277	-4602
SRV	1197	283	845	8251	2645	1447
	-1301	-257	-744	-10126	-2255	-1669
EC25 DW+SRV+PS+SSE+TH	3499	5569	5392	220583	25214	37961
	-5034	-5412	-5216	-231744	-28326	-33898
Abs EC 25	5034	5569	5392	231744	28326	37961
Enveloping Load Combination	6329	5709	5555	245496	32916	39259
EC 25/Envelop	0.80	0.98	0.97	0.94	0.86	0.97

Table Notes:

1. No submerged structure loads.
2. Reference: [7.4.42 Pages 68 of 97]
3. 0.0 ΔP PS Accident Condition Loading for External Piping – Load Condition Adjustment Factor for NO is 1.11 [Section 5.1 Table 13].
4. Enveloping Event Combination: Reference [7.4.42 Pages 68 of 97]

5. Static Load Conditions were combined with consideration of the sign.
6. Dynamic Load Conditions were combined by SRSS.

Table I-101 - Penetration Loads 0.0 ΔP NO X-205

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-371	-3	13	711	1271	647
	-371	-3	13	711	1271	647
THDES	0	341	242	0	0	4416
	-674	0	0	-26625	-10643	0
TH	0	172	140	0	0	2733
	-371	0	0	-12495	-5718	0
OBE	3225	5308	5054	197624	23545	34196
	-3225	-5308	-5054	-197624	-23545	-34196
SSE	2663	4430	4238	219582	23113	29834
	-2663	-4430	-4238	-219582	-23113	-29834
PS x 1.11	1967	1055	1213	8548	3831	5480
	-2792	-1117	-1241	-8847	-3637	-5108
SRV	1197	283	845	8251	2645	1447
	-1301	-257	-744	-10126	-2255	-1669
EC25 DW+SRV+PS+SSE+TH	3592	5588	5419	220614	25272	38043
	-5201	-5433	-5244	-231777	-28378	-33969
Abs EC 25	5201	5588	5419	231777	28378	38043
Enveloping Load Combination	6329	5709	5555	245496	32916	39259
EC 25/Envelop	0.82	0.98	0.98	0.94	0.86	0.97

Based on a review of the results from Table I-101 the previous enveloping EC used to calculation the Torus Shell and Nozzle stresses remains bounding. The free shell stress results were selected from the nearest element to penetration X-205. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. Since the envelop selected for the penetration loads was unaffected the free shell stress results selected remain valid.

X-205 BRANCH LINE REVIEW

No Branch Lines were analyzed in the penetration.

X-205 VALVE REVIEW

The reported valves/pump accelerations from Reference 7.4.42, Section 7.7 are shown in Table I-102 for the two valves in the piping system. The Load Condition Adjustment Factor of 1.11 for 0.0 ΔP PS Accident Condition was used to obtain the acceleration contribution from 0.0 ΔP PS NO [Section 5.1 Table 13].

Table I-102 - Reported Valves/Pump Accelerations X-205 (g)

27AOV-117	SSE	SRV	Max PS	0.0 ΔP PS NO (1.11 x Max PS)
X	1.739	0.254	0.354	0.393
Y	0.072	0.004	0.013	0.014
Z	1.201	0.266	0.334	0.371
27AOV-118				
X	1.235	0.250	0.427	0.474
Y	0.111	0.004	0.015	0.017
Z	0.966	0.224	0.341	0.379

Table I-103 - Valves/Pump Accelerations 0.0 NO X-205 (g)

Acceleration g's	27AOV-117			27AOV-118		
	Actual	Allowable	Ratio	Actual	Allowable	Ratio
a_H	2.21	2.48	1.12	1.71	2.48	1.45
a_V	0.07	1.12	16.00	0.11	1.12	10.18

Table Notes:

1. Reference: 7.4.42, Section 7.7.
2. Accelerations were combined as outlined in X-205 Revision 2 Section 7.7.
3. 0.0 ΔP PS Accident Condition Loading for External Piping – Load Condition Adjustment Factor for NO is 1.11 [Section 5.1 Table 13].

X-205 Revision 2 reported that the accelerations of Valves 27AOV-117 and 27AOV-118 meet the design criteria [7.4.42 Section 7.7]. Updated Valve Acceleration values reported in Table I-103 demonstrate acceptability for continued service for 0.0 ΔP NO.

Table I-104 - X-205 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	21	DBA CO	2.21
Support	21	DBA CO	-
Penetration	21	DBA CO	1.70
Valves	25	0.0 ΔP NO	1.12

X-202B/G Vacuum Relief Line

The calculation reviewed is Penetration X-202B/G R0, “Torus Attached Piping Analysis,” July 1983 [7.4.32].

X-202 B/G PIPE STRESS REVIEW

Table I-105 - Reported Pipe Stress Results X-202B/G

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	4,173	1.0 S_H = 15,000
1	3	P+N+EQ+SRV	20,292	1.8 S_H = 27,000
2	16	P+N+0.0 ∆P PS	9,759	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	27,926	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ∆P PS	21,542	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	21,723	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.32

Adjusted Pipe Stress Results from X-202B/G

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-106:

Table I-106 - Individual Load Condition Contributions per EC X-202B/G

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	4,173	1.0 SH = 15,000	17,100	4.10
1	3	P+N+EQ+SRV	20,292	1.8 SH = 27,000	30,780	1.52
2	16	P+N = 4173 0.0 ∆P = 5586	9,759	2.4 SH = 36,000	41,040	4.21
3	21	P+N+EQ +DBA CO	27,926	2.4 SH = 36,000	41,040	1.47
4	25 - 1.7 ∆P	P+N+EQ+SRV = 20,292 1.7 ∆P= 1250	21,542	2.4 SH = 36,000	41,040	1.91
4	25 – 0.0 ∆P (Accident)	P+N+EQ+SRV = 20,292 0.0 ∆P = 5586	25,878	2.4 SH = 36,000	41,040	1.59
4	25 – 0.0 ∆P (NO)	P+N+EQ+SRV = 20,292 0.0 ∆P = 5586 x 1.11 = 6200	26,492	2.4 SH = 36,000	41,040	1.55
5 (4)	27	P+N+EQ+SRV =17745 Post CH = 2387	20,132	2.4 S_H = 36,000	41,040	2.04

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. Adjustment for Accident Condition 0.0 ∆P PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13. This largest adjustment factor was conservatively used for EC 25 adjustment.
3. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ∆P NO Torus External Piping stress and the EC 21 stress is still the controlling EC.

X-202 B/G PIPE SUPPORT REVIEW

No pipe support loads were reported in the calculation [7.4.32]. However, supports, PFSK – 1951, 2506, 2463 and 2280 are listed in the calculation. Based on a review of a sample of the calculations they were prepared using Service Level A Allowable Stress Values with knowledge of the 0.0 ∆P Accident Load Condition [7.4.55 & 7.4.56]. The 0.0 ∆P PS NO ECs are Service Level B. Therefore, the increase in allowable stress value by1.33 for Service Level B will more than accommodate the 11% increase in the 0.0 ∆P PS NO Load Condition and associated ECs.

X-202 B/G PIPE PENETRATION REVIEW

X-202G VP Penetration Evaluation

The torus shell penetration X-202G was evaluated based on the external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 15 was considered by TES to be controlling for the VP Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Therefore, only EC 15 was evaluated and reported. Review the previous results and determine if the assumption that the EC 15 is bounding still applies (Table I-107 to Table I-116 - Updated VP Penetration Stress Results X-202G).

Table I-107 - Reported VP Penetration Stress Results X-202G

X-202G	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Penetration	18075	$1.5S_{MC}$ = 28,900	33,000	1.83
P_M	Nozzle	16200	$1.0S_{MC}$ = 19,300	22,000	1.36

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported loads were from 7.4.32 Page 4 of 42.

Table I-108 - Reported Individual Pipe/ VP Penetration Loads X-202G

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-2340	-899	-920	-53789	829	629
TH	-2340	-4120	-4140	-256000	1390	-46800
EQ	2450	18370	5770	116090	8240	221670
SRV1	160	580	1790	61590	1330	3910
CO	380	2200	10110	325580	6580	14450
CH	70	420	2130	62030	1270	2480
PS1 (0.0 ΔP) Accident	200	1140	6530	194020	3560	7640
PS2 (1.7 ΔP)	80	350	1910	57390	970	2260
SRV2	150	420	1900	63170	1330	4650

Table Notes:

1. Reported loads were from 7.4.32 Page 12 of 42.

Table I-109 - Pipe/ VP Penetration PS Load Adjusted for 0.0 ΔP NO X-202G

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ΔP) Accident	200	1140	6530	194020	3560	7640
PS1 (0.0 ΔP) Normal Operation	222	1265	7248	215362	3952	8480

Table I-110 - Reported Pipe/ VP Penetration EC Forces and Moments X-202G

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	7136	20226	13625	595909	11013	230827
16	N+TH+0.0 ΔP PS	4880	6159	11590	503809	5779	55069
21	N+TH+SSE+CO	7159	20367	18015	734319	13047	231338
25	N+TH+SSE+SRV+1.7 ΔP PS	7137	20224	13572	594939	10975	230825

Table I-111 - Adjusted Pipe/ VP Penetration EC Forces and Moments X-202G

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	7136	20226	13625	595909	11013	230827
16 (1 & 3)	N+TH+0.0 ΔP PS	4902	6284	12308	525151	6171	54651
21	N+TH+SSE+CO	7159	20367	18015	734319	13047	231338
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ΔP PS	7145	20273	16094	662769	11776	229766
EC25 0.0 ΔP PS/EC 15		1.00	1.00	1.18	1.11	1.07	1.00
Average		1.06			1.06		

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. Dynamic loads were combined by SRSS.

Table I-112 - Reported Individual VP/ Penetration Loads X-202G

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	6544	9011	102	22529	18722	870950
Thrust	11513	1389	870	27726	236796	133440
SSE	2450	18370	5770	116090	8240	221670
PS1 (0.0 ΔP) Accident	40264	57906	3138	349472	5288717	834668
PS2 (1.7 ΔP)	41973	58189	3314	284396	5791546	790219

Table Notes:

1. Reported loads were from 7.4.32 Page 18 of 42.

Table I-113 – VP/ Penetration PS Load Adjusted for 0.0 ΔP NO X-202G

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ΔP) Accident	40264	57906	3138	349472	5288717	834668
PS1 (0.0 ΔP) Normal Operation (x 1.05)	42277	60801	3295	366946	5553153	876401
Thrust	160540	12531	787	93778	231361	674662
Thrust (0.0 ΔP) Normal Operation (x 1.11)	178199	13909	874	104094	256811	748875

Table I-114 - Reported VP/ Penetration EC Forces and Moments X-202G

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
16	N+TH+0.0 ΔP PS	207348	79448	4027	465779	5538800	2380280
25	N+TH+SSE+SRV+1.7 ΔP PS	220570	81120	5073	428429	6278425	2469271

Table I-115 - Adjusted VP/ Penetration EC Forces and Moments X-202G

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
16	N+TH+0.0 ΔP PS	227021	83722	4270	493568	5828686	2496226
25	N+TH+SSE+SRV+0.0 ΔP PS NO	227321	83735	4360	494383	5833509	2501695
EC25 0.0 ΔP NO/ EC25 1.7 ΔP NO		1.03	1.00	1.18	1.11	1.07	1.00
Average		1.07			1.06		

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. Static loads were combined by signed summation and dynamic loads were combined by SRSS.

Based on a review of the Table I-111- Adjusted EC Forces and Moments EC 25 is the bounding Event Combination for NO with 0.0 ΔP. The penetration stresses are updated with the stress multiplied by the Pipe/ Penetration plus the VP/ Penetration Average Adjustment of (1.07 + 1.06/2) = 1.07 as listed in Table I-116.

Table I-116 - Updated VP Penetration Stress Results X-202G

X-202G	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Penetration	19,340	$1.5S_{MC}$ = 28,900	33,000	1.71
P_M	Nozzle	17,334	$1.0S_{MC}$ = 19,300	22,000	1.27

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. The Stress Adjustment as described above is 1.07.

X-202B Torus Penetration Evaluation

The torus shell penetration X-202B was evaluated based on external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. The free shell stress results were selected from the nearest element to penetration X-202B. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid.

Therefore, only EC 21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21 is bounding still applies (Table I-117 to Table I-121).

Table I-117 - Reported Torus Penetration Stress Results X-202B

X-202B	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Penetration	17817	$1.5S_{MC}$ = 28,900	33,000	1.85
P_M	Nozzle	16111	$1.0S_{MC}$ = 19,300	22,000	1.37

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.32 Page 23 and 26 of 42.

Table I-118 - Reported Individual Torus Penetration Loads X-202B

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-169	0	-250	-8759	-839	-2120
TH	-699	2300	2570	60300	-3410	-148
EQ	2990	3870	5790	244330	8770	3530
SRV1	1522	720	1087	24878	1226	1330
CO	15533	4311	6179	192780	9038	18938
CH	3599	929	1354	49226	1965	4690
PS1 (0.0 ΔP) Accident	11599	2700	4262	165030	4793	8438
PS2 (1.7 ΔP)	3572	1092	1399	58182	1508	2389

Table I-119 - PS Load Adjusted for 0.0 ∆P NO X-202B

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ∆P) Accident	11599	2700	4262	165030	4793	8438
PS1 (0.0 ∆P) Normal Operation	12875	2997	4731	183183	5320	9366

Table I-120 - Reported EC Forces and Moments X-202B

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	5788	6345	8865	319537	13320	8287
16	N+TH+0.0 ∆P PS	12467	5000	7082	234089	9042	10706
21	N+TH+SSE+CO	16686	8093	11288	380284	16843	21532
25	N+TH+SSE+SRV+1.7 ∆P PS	5769	6385	8875	321450	13232	6733

Table I-121 - Adjusted EC Forces and Moments X-202B

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	5788	6345	8865	319537	13320	8287
16 (1 & 3)	N+TH+0.0 ∆P PS	13743	5297	7051	234724	9569	11634
21	N+TH+SSE+CO	16686	8093	11288	380284	16843	21532
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ∆P PS	14173	7247	9876	357927	14580	12365
EC25 0.0 ∆P PS/EC 21		0.85	0.895	0.88	0.94	0.87	0.57

Table Notes:

1. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. Static loads were combined by signed summation and dynamic loads were combined by SRSS.

Based on a review of the Table I-121- Adjusted EC Forces and Moments X-202B, EC 21 remains bounding for 0.0 ∆P NO.

X-202 B/G BRANCH LINE REVIEW

There are no branch lines associated with the X-202 B/G piping evaluation [7.4.32].

X-202 B/G Valve and Pump Review X-202 B/G

The stresses for valves/pump are shown in Table I-122.

Table I-122 - Valves and Pump Stresses X-202B/G

Valve/Pump Designation	Maximum Stress psi	1.2 S_H psi	Allowable/ Maximum Stress
VB2	13498 (2)	20520	1.52
AOV-101B	3471	20520	5.91
AOV-101A	3445	20520	5.96
VB7	295	20520	69.56
VB6	295	20520	69.56

Table Notes:

1. Reference: 7.4.32 Page 1 of 8.
2. Maximum stress is EC 21 for the valve.
3. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Adequate margin exists to demonstrate that all valves will perform their design function using the increased pipe stress (11%) EC 25 for 0.0 ΔP PS NO.

Table I-123 - X-202 B/G Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	21	DBA CO	1.47
Support	-	-	-
X-202G Penetration	25	0.0 ΔP PS NO	1.27
X-202B Penetration	21	0.0 ΔP PS NO	1.37
Branch Line	-	-	-
Valves	21	DBA CO	1.52

X-220 Vent Purge Outlet Piping

The calculation reviewed is Penetration X-220 R1 by TES, "Torus Attached Piping Analysis," July 1983 [7.4.34]. This calculation was revised as R2 based on EC 619886 Markup of X-220 [7.4.41]. The revision 2 by AMEC Foster Wheeler (AFW) is to address the material and weight discrepancy related to line 30"-N-151A-21 for Torus Penetration X-205 and X-220 Penetration nozzle material found by CR-JAF-2016-05223 [7.4.41 Page 7 of 93].

X-220 PIPE STRESS REVIEW

Revision 2 of the calculation X-220 recalculated the governing Mark I load combinations using the correct piping material and class [7.4.41]. The Mark I load combinations added the static loads to the SRSS of the dynamic loads as show in section 7.5 of the Revision 2 calculation. The results are shown in Table I-124.

Table I-124 - Reported Pipe Stress Results from X-220

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	P+DW	3,028	1.0 S_H = 15,000
1a		P+DW+OBE	9,733	1.2 S_H = 18,000
1b		P+DW+SRV	9,981	1.2 S_H = 18,000
1c	3	P+DW+SSE + SRV	16,295	1.8 S_H = 27,000
3	21	P+N+EQ+DBA CO	14,429	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+0.0 ∆P PS	16,384	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+ CH	16,300	2.4 S_H = 36,000

Table Notes:

1. The Pool Swell Stresses used in the pipe stress load combinations are the maximum/ minimum stresses from both Pool Swell Load Cases (PS1 and PS2). Therefore, P + DW + PS1 is bounded by P + DW + SSE + PS+ SRV
2. Reference: 7.4.41 Page 53 of 93.

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-125:

Table I-125 - Individual Load Condition Contributions per EC X-220

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	3,028	1.0 SH = 15,000	17,100	5.65
1a		P+DW+OBE OBE = 6705	9,733	1.2 SH = 27,000	20,520	2.11
1b		P+DW+SRV SRV=6953	9,981	1.2 SH = 27,000	20,520	2.06
1c	3	P+DW+SSE + SRV SSE=11299	16,295	1.8 SH = 27,000	30,780	1.89
3	21	P+N+EQ +DBA CO DBACO=1522	14,429	2.4 SH = 36,000	41,040	2.84
4	25 – Max (0.0 ΔP Accident, 1.7 ΔP)	P+N+EQ+SRV+ 0.0 ΔP PS 0.0 ΔP PS=1540	16,384	2.4 SH = 36,000	41,040	2.50
4	25 – 0.0 ΔP (NO)	P+N+EQ+SRV +0.0 ΔP PS NO 0.0 ΔP PS NO = 1540 X 1.11 = 1709	16,405	2.4 SH = 36,000	41,040	2.50
5	27	P+N+EQ+SRV+ CH CH = 364	16,300	2.4 S_H = 36,000	41,040	2.52

Table Notes:

1. The Pool Swell Stresses used in the pipe stress load combinations are the maximum/minimum stresses from both Pool Swell Load Cases (PS1 and PS2). Therefore, P + DW + PS1 is bounded by P + DW + SSE + PS+ SRV
2. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment.
3. SH Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.
4. Reference: 7.4.41 Page 53 of 93.

Based on the adjustment EC 25 which incorporated the 0.0 ΔP NO Torus External Piping stress the total stress is 16,405 psi. The increase in stress is much less than 1% (16,405/16,384 – 1) and therefore negligible.

X-220 PIPE SUPPORT REVIEW

No pipe support loads were listed in 7.4.34. Pipe support load summaries were provided in 7.4.41. The loads conservatively used larger of the Pool Swell Load Cases (PS1 and PS2) [7.4.41 Page 89 of 93]. The pipe supports (modified BFSK-877, BFSK-4262 (Snubber & Strut)) and were evaluated and considered structurally adequate in calculation JAF-CALC-17-00083 based on the conservative loading condition [7.4.48]. The Table below lists the individual EC 25 Load Conditions and summarizes EC 25 as reported in the calculation and with the PS adjusted for 0.0 ∆P NO.

Table I-126 - Individual Support Load Condition Contributions EC 25 X-220

Load Condition	PFSK-4262 Strut Load lbs	PFSK-4262 Snubber Load lbs
DW	1077	0
TH	5389	0
SSE	3103	6537
PS	712	273
PS X 1.11	790	303
SRV	3221	205
EC 25 0.0 ∆P Accident	10995	6546
EC 25 0.0 ∆P NO	11008	6547
EC 25 0.0 ∆P NO/ EC 25 0.0 ∆P Accident	1.00	1.00

BFSK-877	SUPPORT LOADS lbs/in-lbs					
Load Condition	Fx	Fy	Fz	Mx	My	Mz
DW	677	-2105	334	-25071	150	51806
	677	-2105	334	-25071	150	51806
TH	0	2475	0	157850	18027	0
	-1820	0	-1404	0	0	-137080
SUM DW+TH	677	370	334	132779	18177	51806
	-1143	-2105	-1070	-25071	150	-85274
SSE	1279	801	1851	150559	60206	105780
	-1279	-801	-1851	-150559	-60206	-105780
PS	539	662	267	14103	4928	41525
	-382	-940	-184	-19205	-5498	-28335
PS x 1.11	598	735	296	15654	5470	46093
	-424	-1043	-204	-21318	-6103	-31452
SRV	2433	4141	1195	85100	3710	182903
	-2368	-4253	-1165	-88488	-4009	-178572
SRSS	2801	4269	2219	173519	60521	215331
	-2718	-4429	-2195	-175690	-60589	-209476
EC25 0.0 ΔP Accident	3478	4639	2553	306298	78698	267137
	-3861	-6534	-3265	-200761	-60439	-294750
Max ABS Accident	3861	6534	3265	306298	78698	294750
EC25 0.0 ΔP NO	3490	4651	2557	306431	78745	268064
	-3868	-6557	-3267	-201004	-60497	-295194
Max ABS NO	3868	6557	3267	306431	78745	295194
EC 25 0.0 ΔP NO/ EC 25 0.0 ΔP Accident	1.00	1.00	1.00	1.00	1.00	1.00

Table Notes

1. The Pool Swell Stresses used in the pipe stress load combinations are the maximum/minimum stresses from both Pool Swell Load Cases (PS1 and PS2). Therefore, P + DW + PS1 is bounded by P + DW + SSE + PS+ SRV
2. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment.
3. Load Conditions are combined as described in Reference: 7.4.41 Pages 83-88 of 93.

Based on a review of Table I-126 and because the PS load is relatively small compared to the SRV and SSE the change in dynamic loading from 1.7 ΔP NO to 0.0 ΔP NO is negligible. The Supports are acceptable for continued service at 0.0 ΔP NO.

X-220 PIPE PENETRATION REVIEW

The torus shell penetration X-220 was evaluated in Revision 2 based on the external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18]. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid.

A bounding envelop of ECs was used for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Review the previous results and determine if the assumption that the EC 15 is bounding still applies (Table I-127 to Table I-130).

Table I-127 - Reported Penetration Stress Results X-220

X-220	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Shell at Pad	15158	$1.5S_{MC}$ = 28,900	33,000	2.18
P_I	Torus Shell at Nozzle	14651	$1.5S_{MC}$ = 28,900	33,000	2.25
P_M	Nozzle	12972	$1.0S_{MC}$ = 19,300	22,000	1.70

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.41 Page 75, 76 and 82 of 93.

Table I-128 - Reported Individual Penetration Loads X-220

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	2271	-148	-286	-489	51	-19
	2271	-148	-286	-489	51	-19
TH	2475	0	0	0	18539	0
	0	-3814	-6640	-53161	0	-11914
EQ	958	4832	895	133671	5969	10940
	-958	-4832	-895	-133671	-5969	-10940
SRV1	8114	374	966	890	335	470
	-7901	-367	-993	-981	-359	-475
Max PS	1793	136	171	732	398	658
	-1263	-253	-249	-643	-439	-765

Table Notes:

1. Individual Load Conditions are taken from 7.4.41 Attachment X Member 1.

Table I-129 - PS Load Adjusted for 0.0 ∆P Normal Operation X-220

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
EC 25 0.0 ∆P Accident	13111	8815	8286	187326	24582	22910
EC 25 0.0 ∆P NO	13155	8816	8291	187327	24585	22916

Table Notes:

1. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].

Table I-130 - Reported Envelope/ EC 25 0.0 ∆P PS NO – Forces and Moments X-220

EC	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
Max	Envelop	13111	11589	12644	228567	38264	31787
EC 25	N+TH+SSE+SRV +0.0 ∆P PS NO	13155	8816	8291	187327	24585	22916
	EC 25/ Max Envelope	1.00	0.76	0.66	0.82	0.64	0.72

Table Notes:

1. Envelope is taken from 7.4.41 Page 65 of 93.

Based on the comparison in Table I-130 the change to the maximum envelope is negligible and the X-220 penetration results reported in Revision 2 and Table I-127 remain unchanged. The X-220 penetration is adequate for continued service at 0.0 ∆P NO.

X-220 BRANCH LINE REVIEW

No Brach line was analyzed in the penetration.

X-220 VALVE REVIEW

The reported valves/pump accelerations from Reference 7.4.41 Section 7.7 are shown in Table I-131 for the two valves in the piping system. The Load Condition Adjustment Factor of 1.11 for 0.0 ∆P PS Accident Condition was used to obtain the acceleration contribution from 0.0 ∆P PS NO [Section 5.1 Table 13].

Table I-131 - Reported Valves/Pump Accelerations X-220 (g)

27AOV-115	SSE	SRV	Max PS	0.0 ∆P PS NO (1.11 x Max PS)
X	0.418	0.039	0.061	0.068
Y	0.294	3.253	0.914	1.015
Z	0.596	0.076	0.125	0.139
27AOV-116				
X	0.616	0.079	0.135	0.150
Y	0.356	3.910	1.098	1.219
Z	1.034	0.158	0.274	0.304

Table I-132 - Valves/Pump Accelerations 0.0 NO X-220 (g)

Acceleration g's	27AOV-115			27AOV-116		
	Actual	Allowable	Ratio	Actual	Allowable	Ratio
a_H	0.75	4.09	5.45	1.26	4.09	3.25
a_V	3.42	7.43	2.17	4.11	7.43	1.81

Table Notes:

1. Reference: 7.4.41, Section 7.7.
2. Accelerations were combined as outlined in X-220 Revision 2 Section 7.7.
3. 0.0 ΔP PS Accident Condition Loading for External Piping – Load Condition Adjustment Factor for NO is 1.11 [Section 5.1 Table 13].

X-220 Revision 2 reported that the accelerations of Valves 27AOV-115 and 27AOV-116 meet the design criteria [7.4.41 Section 7.7]. Updated Valve Acceleration values reported in Table I-132 demonstrate acceptability for continued service for 0.0 ΔP NO.

Table I-133 - X-220 Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP PS NO	2.50
Support	-	-	
Penetration	25	0.0 ΔP PS NO	1.70
Branch Line	-	-	
Valves	25	0.0 ΔP PS NO	1.81

X-210B & X-211B RHR Discharge Piping

The calculations reviewed are Penetration X-210B/211B R2, "Torus Attached Piping Analysis," September 1983 by TES [7.4.36], and CDE-87-1223-C-46 R1, "Pipe Stress Analysis of RHR Lines" by NYPA after a CIV 10MOV-39B replacement in X-210B piping [7.4.37].

X-210B/211B PIPE STRESS REVIEW

The NYPA report was prepared to demonstrate acceptability of a new valve 10MOV-39B. The report concluded that the TES pipe stress results were bounding as given below in Table I-134. The TES results will be adjusted to account for 0.0 ΔP NO

Table I-134 - Reported Pipe Stress Results from X-210B/211B – TES & NYPA

TES TAP	EC	Load Conditions	TES Pipe Stress psi	NYPA pipe stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	7,825	4,476	1.0 S_H = 15,000
1	3	P+N+EQ+SRV	25,298	16,477	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	35,073	31,724	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	29,811	20,990	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	34,609	25,788	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	25,573	16,752	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.36 Page 2 of 2 & 7.4.37 Page 80, 84 of 93.

Adjusted Pipe Stress Results from X-210B/211B

Based on the results from the stress calculation, the maximum internal PS pipe stress was calculated at Node 50 [7.4.36 Page 4-5 of 22]. Thus, LC4 is recalculated at Node 50 based on the 0.0 ΔP NO condition as given in Table I-135. The individual load condition stress results were combined by summation of the signed Static stress results (DW+SLB) and SRSS of the dynamic stress results (EQ, SRV, PS (internal + external):

Table I-135 - LC4 at Node 50 for 0.0 ΔP NO (1) X-210B/211B - TES

Stress psi	Load	Value	Reference
A	DW	1148	[7.4.36 Page 10 of 22]
B	SLP	1488	[7.4.36 Page 10 of 22]
C	EQ	16428	[7.4.36 Page 6 of 22]
D	SRV	5953	[7.4.36 Page 6 of 22]
E	PS1 Internal	17267	[7.4.36 Page 7 of 22]
F	PS1 External	12337	[7.4.36 Page 7 of 22]
G	LC4 0.0 ΔP Accident	37,012	$=A+B+(C^2+D^2+(E+F)^2)^{1/2}$
H	LC4 0.0 ΔP NO	38,187	$=A+B+(C^2+D^2+(E*1.00+F*1.11)^2)^{1/2}$
I	Reconciled B31.1 Allowable Stress Value psi	41,040	2.4 S_H = 2.4*17,100 psi Section 2.13 Table 5
J	Allowable/LC4	1.07	I/H

Table Notes:

1. The location of DW and SLP loads were from Node 50. Other loads were from maximum reported values. $SLP = \frac{P\,x\,d^2}{D^S - d^2} = \frac{150\,psi\,x\,15.25^2 in^2}{16^2\,in^2 - 15.25^2 in^2} = 1488\,psi$
2. The PS Load Condition is the Combination of PS loads from the piping external to the torus and internal to the torus.
3. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ΔP Accident Conditions [7.4.36 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping.
4. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↑ Upload Phase Accident Condition to obtain 0.0 ΔP PS ↑ Upload NO for the Torus Internal Structure is 1.0 based on the controlling Froth Load Condition discussed in Note 3 above [Section 5.1 Table 13].
5. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase Accident Condition to obtain 0.0 ΔP PS ↓ Download NO for the Torus External Piping Load Condition is 1.11 [Section 5.1 Table 13].
6. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

The X210B/ X211B RHR discharge pipe stress analysis was reviewed during the CIV 10MOV-39B replacement and it was determined that the TES Mk I Program evaluation was conservative [7.4.37 Page 84 of 93]. The updated TES evaluation demonstrates that the piping design is adequate for continued service at 0.0 ΔP NO.

X-210B/211B PIPE SUPPORT REVIEW

Pipe Support Loads for the Combined PS ECs were reviewed by TES in the X-210/ X-211 B Calculation [7.4.36 Pages 6 & 7 of 83]. The support loads were also reviewed after 10MOV-39B replacement in NYPA calculation [7.4.37 Page 56-77 of 93]. The pipe support load results for dynamic loads from NYPA are listed in Table I-136.

Table I-136 – X-210B/211B Pipe Support Loads – TES & NYPA

Node No.	Dynamic Loads from NYPA lbs	0.0 ΔP PS Load Condition Adjustment Factor	Adjustment Δ Dynamic Loads from NYPA lbs	Total Loads from NYPA lbs	Adjusted Total Loads from NYPA lbs	Adjusted Total Load/ Total Load Ratio
7	3224 3014	1.05	161 151	3394 3767	3550 3903	1.05 1.04
75	9630	1.05	481	11486	11960	1.04
105	7887	1.11	868	15134	15782	1.04
126	4654	1.11	512	16408	16560	1.01
133	4654	1.11	512	17411	17554	1.01
156	3539	1.11	389	4234	4565	1.08
160	3305	1.11	364	4639	4904	1.06
175	3117	1.11	343	20034	20116	1.00
190	4271	1.11	470	4698	5129	1.09
205	1562	1.11	172	4367	4447	1.02
210	1970	1.11	217	2624	2791	1.06
240	1395	1.11	153	3544	3664	1.03
245	1548	1.11	170	2466	2576	1.04
251	2754	1.11	303	4102	4311	1.05
275	431	1.11	47	3725	3740	1.00
305	1980	1.11	218	2359	2544	1.08
337	900	1.11	99	17925	18010	1.01
440	2792	1.11	307	3106	3385	1.09
445	310 310	1.11	34 34	1919 1980	1925 1986	1.00 1.00

Table Notes:

1. References: 7.4.36 Page 6 of 83 & 7.4.37 Page 56- 77 of 93.
2. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ΔP Accident Conditions [7.4.36 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/21674). Note: Impact loads are also applied but TES noted it does not have a significant effect on the piping. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
3. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↑ Upload Phase Accident Condition to obtain 0.0 ΔP PS ↑ Upload NO for the Torus Internal Structure is 1.0 based on the controlling Froth Load Condition discussed in Note 3 above [Section 5.1 Table 13]. The exception is Node 7 which is affected as discussed in Note 2 by Pool Impact and Drag. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↑ Upload Phase Accident Condition to obtain 0.0 ΔP PS ↑ Upload NO for the Torus Internal Structures due to Impact and Drag is 1.05.
4. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase Accident Condition to obtain 0.0 ΔP PS ↓ Download NO for the Torus External Piping Load Condition is 1.11 [Section 5.1 Table 13].

The load increase for 0.0 ΔP NO is less than 10% for the PS EC. This increase can easily be accommodated by the existing support designs. JAF supports were designed to Service Level A Allowable Stress Values. The 0.0 ΔP PS case is listed in Table 5-2 of the PUAAG as Level B [7.2.1]. A commensurate increase in support load would be easily accommodated by the 1.33 increase in the Service Level B Allowable Stress Value for EC 25.

X-210B/211B PIPE PENETRATION REVIEW

The torus shell penetrations X-210B and X-211A/B were evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

X-210B

EC 16 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results using EC15 for the maximum free shell stresses. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid. Review the previous EC 16 results and determine if the assumption that the EC 16 is bounding still applies (Table I-137 to Table I-140).

The penetration loads for X-210B were reviewed after 10MOV-39B replacement by NYPA in 7.4.37 Page 85-87 of 93. Based on the comparison of TES's and NYPA's maximum loads, stresses and usage factor at Penetration X-210B, the NYPA values are bounded by the values reported by TES [7.4.37 Page 85 of 93]. Therefore, the TES original calculation for Penetration X-210B is still valid for the 1.7 ΔP PS conditions after the 10MOV-39B replacement.

Table I-137 - Reported Penetration Stress Results X-210B - TES

X-210B	Penetration Location	Stress psi	Reported Allowable psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	16862	$1.5S_{MC}$ = 28,900	33,000	1.96
P_L	Torus Shell at Reinforcing Pad	26412	$1.5S_{MC}$ = 28,900	33,000	1.25
P_M	Nozzle	12536	$1.0S_{MC}$ = 19,300	22,000	1.76

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.36 Page 28 and 31 of 83.

Table I-138 - Reported Individual Penetration Loads X-210B - TES

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-2456	-2916	227	-17736	1104	6576
TH	-40	539	-2080	153096	11460	2016
EQ	9729	2259	1065	97632	10656	29316
SRV	970	6810	6410	41350	560	470
CO	7200	16913	18882	228350	6104	23564
PS1 (0.0 ∆P) Accident	11638	19040	4447	79846	3366	22424
PS1 (0.0 ∆P) Accident - Submerged	23620	14870	13954	5000	1000	1000

Table Notes:

1. Reported loads were from 7.4.36 Pages 14 - 18 of 83.
2. SRV loads were taken from the Test Model Output on 7.4.36 Page 17 of 83.

Table I-139 - PS Load Adjusted for 0.0 ∆P NO X-210B - TES

Load Condition	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
0.0 ∆P PS Accident	11638	19040	4447	79846	3366	22424
0.0 ∆P PS NO	12918	21134	4936	88629	3736	24891
Submerged 0.0 ∆P PS Accident	23620	14870	13954	5000	1000	1000
Submerged 0.0 ∆P PS NO	23620	14870	13954	5000	1000	1000

Table Notes:

1. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ∆P Accident Conditions [7.4.36 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
2. The Load Condition Adjustment Factor for the 0.0 ∆P PS ↑ Upload Phase Accident Condition to obtain 0.0 ∆P PS ↑ Upload NO for the Torus Internal Structure is 1.0 based on the controlling Froth Load Condition discussed in Note 3 above [Section 5.1 Table 13].

3. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase Accident Condition to obtain 0.0 ΔP PS ↓ Download NO for the Torus External Piping Load Condition is 1.11 [Section 5.1 Table 13].

Table I-140 - Reported/ Adjusted EC – Forces and Moments X-210B - TES

EC	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
16 Reported	N+TH+0.0 ΔP PS Accident	37754	36287	20254	220206	16930	32016
21 Reported	N+TH+SSE+ CO	14599	19440	20765	353706	24844	46204
16 Adjusted	N+TH+0.0 ΔP PS NO	39034	38381	20743	228989	17300	34483
25 Adjusted	N+TH+SSE+ SRV+0.0 ΔP PS NO	40320	39089	21830	276810	24239	47707
SRSS - EC 16 Reported		56146			223164		
SRSS - EC25 0.0 ΔP NO Adjusted		60251			281935		
SRSS - EC25 0.0 ΔP NO/ SRSS - EC 16 Reported		1.07			1.26		

Table Notes:

1. The 0.0 ΔP PS Accident Condition Load Condition Adjustment Factor for External Piping NO is 1.11 [Section 5.1 Table 13]
2. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ΔP Accident Conditions [7.4.36 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
3. 0.0 ΔP Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.00 [Section 5.1 Table 13]
4. The PS Internal and External load conditions are combined by summation. Where: E is External to the Torus and I is Internal to the torus:

$$\text{EC 25:=} \ |\mathrm{DW} + \mathrm{TH}| + \sqrt{(\mathrm{PSI} + \mathrm{PSE})^2 + \mathrm{SRV}^2 + \mathrm{SSE}^2}$$

5. The SRSS of the three forces and the SRSS of the three moments and comparison of the ratio of the Adjusted EC25 0.0 ΔP PS NO and the reported EC 16 0.0 ΔP PS Accident Condition will be used to update the External Stress evaluation for the X-210B Torus Penetration. The maximum ratio is 1.26.

Based on a review of the Table I-140- Reported/ Adjusted EC – Forces and Moments EC 25 is bounding for 0.0 ΔP NO. Therefore, the local membrane stress for the penetration and nozzle will be reevaluated for 0.0 ΔP PS NO.

Table I-141 - Local Membrane Stress at Penetration X-210B

Torus Shell at Nozzle intersection stress psi	External Stress		Free Shell Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	4347	5477	12200	12200	16547	17677
σ_x	4216	5312	2729	2729	6945	8041
$\tau_{x\theta}$	1593	2007	174	174	1767	2181
			Max Principal Stress		16862	18148
Torus Shell at Edge of Reinforcement Stress psi	External Stress		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	16656	20987	9186	9186	25842	30173
σ_x	11350	14301	6948	6948	18298	21249
$\tau_{x\theta}$	1767	2226	383	383	2150	2609
			Max Principal Stress		26412	30880
Nozzle stress psi	External Stress		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	0	0	12200	12200	12200	15372
σ_x	1019	1177	2729	2729	3748	4616
$\tau_{x\theta}$	1544	1782	174	174	1718	2001
			Max Principal Stress		12536	15732

Table Notes:

1. References 7.4.36 Page 21-30 of 83.
2. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid and are therefore updated by a factor of 1.0.
3. Stress from external load was Updated (multiplied by 1.26) based on the results from Table I-140.
4. External Nozzle Stress was recalculated using the adjusted EC 25 results from Table I-140 based on the original calculation in the X-210B/211B package [7.4.36 Page 20 of 83].
5. Principal stress results are calculated per DISTRES [Section 2.9]:

$$\frac{Sx + Sy}{2} \pm \sqrt{\left(\frac{Sx - Sy}{2}\right)^2 + \tau xy^2}$$

Thus, the penetration stress is updates as in Table I-142. This penetration is adequate.

Table I-142 - Updated Penetration Stress Results X-210B

X-210AB	Penetration Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	18148	$1.5S_{MC}$ = 28,900	33,000	1.82
P_L	Torus Shell at Reinforcing Pad	30880	$1.5S_{MC}$ = 28,900	33,000	1.07
P_M	Nozzle	15732	$1.0S_{MC}$ = 19,300	22,000	1.40

X-211A and X-211B

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and EC15 the maximum free shell stresses. Therefore, only EC 21/15 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21/15 is bounding still applies (Table I-143 to Table I-145). The loading from penetration 211B was higher than that for 211A. Thus, for conservatism the following stress is considered for both X-211A and X-211B [7.4.36 Page 74 of 83].

Table I-143 - Reported Penetration Stress Results X-211A/211B - TES

X-211AB	Penetration Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	12556	$1.5S_{MC}$ = 28,900	33,000	2.63
P_L	Torus Shell at Reinforcing Pad	13672	$1.5S_{MC}$ = 28,900	33,000	2.41
P_M	Nozzle	12436	$1.0S_{MC}$ = 15,100	17,300	1.39

Table Notes:

1. Reconciled allowable stress is from Section 5.1 Table 13.
2. Reported stresses were from 7.4.36 Page 80 and 83 of 83.

Table I-144 - Reported Individual Penetration Loads X-211A/211B - TES

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-103	19	-2	-206	-324	183
TH	255	663	-616	11230	-21385	-17987
EQ	24	895	115	4256	19565	12494
CO	8369	9123	2630	15302	4283	15854
PS	679	335	110	870	555	1595

Table Notes:

1. PS loads for the piping are given in the X210B/ X211B Calculation [7.4.36 Page 66 of 83]. The PS loads reported above include both Froth and Pool Swell Motion. The PS motion would be factored by the Load Condition Adjustment Factor of 1.05

for 0.0 ΔP PS ↑ Upload Phase NO. The Load Condition Adjustment Factor for Froth is 1.0.

Table I-145 - Reported EC 21 & 25 – Forces and Moments X-211A/211B - TES

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
21	N+TH+SSE+CO	8521	9849	3251	26907	41737	37989
25	N+TH+SSE+PS	788	296	122	1071	557	1592

Table Notes:

1. Dynamic Loading is combined by SRSS and added absolutely to Static Loading.
2. The reported EC 25 penetration loads clearly do not control the evaluation.

The PS loads were considered but are small in comparison to the CO loads. Therefore, the penetration is adequate as given in Table I-143.

The X-210B and X-211B Torus Shell Penetrations are adequate for continued service at 0.0 ΔP NO.

X-210B/211B BRANCH LINE REVIEW

The branch line stress calculated shows that the LC4 was the controlling case for all the branch lines in X-210B/211B [7.4.36 Page 10-18 of 22]. The stresses are adjusted for the 0.0 ΔP NO loading condition, shown in Table I-146.

Table I-146 - Adjusted Branch Line Stress Calculation X-210B/211B TES

Stress psi	DW	SLP	SSE EQ	SRV	PS1 EXT	PS1 INT	LC4	Reconciled Allowable	Allowable/ Actual
4" W25-152-16	1148	1488	3807	5953	12337	17267	35235	41040	1.16
4"W20-152-41B	735	1488	3350	1900	7102	0	10997	41040	2.67
4"W20-152-19B	1363	1488	12377	1987	6410	0	17265	41040	1.69
3"W23-152-7B	1189	993	6492	1696	6407	0	11960	41040	2.35
1"W23-152-29B	411	1164	6132	0	0	0	7707	41040	5.33
3"W23-152-6B	424	1164	6519	0	0	0	8107	41040	5.06
4" W20-302-35	269	2311	1187				3767	41040	10.89
1.5"AS-302-55B & 2"AS-302-55B	2324	2152	4222	0	0	0	8698	41040	4.72

Table Notes:

1. References: 7.4.36 Page 10-18 of 22, Section 5.1 Table 13.
2. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11.

3. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ∆P Accident Conditions [7.4.36 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
4. 0.0 ∆P Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.00 [Section 5.1 Table 13].
5. Internal and External PS Loads are combined by summation.

   EC 25:= $|P + DW| + \sqrt{(PSI + PSE)^2 + SRV^2 + SSE^2}$
6. The Allowable Stress Value, S_H is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi. $2.4S_H$=41,040 psi.

The branch line piping is adequate for continued service at 0.0 ∆P NO.

X-210B/211B VALVE REVIEW

The stresses for partial valves/pump in the penetrations are shown in Table I-147.

Table I-147 - Valves/Pump Stresses X-210B/ X-211B

Valve/Pump Designation	Maximum Stress psi	1.2 S_H psi	Allowable/ Maximum Stress
MOV-34B	4631	20520	4.43
MOV-39B	4371	20520	4.69
MOV-26B	945	20520	21.71
MOV-38B	5279	20520	3.89

Table Notes:

1. Reference: 7.4.36 Page 1 of 12.
2. All maximum stress values are from LC 3 (DBA CO).

By inspection of Table I-147 adequate stress margin exists to demonstrate that all valves will perform their design function using the EC 25 0.0 ∆P PS NO pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B. Note that DBACO is a cyclic load condition while PS is a quasi-static load condition. The PS load condition is more localized at the penetration while the DBACO load condition case has been shown to affect the piping and support further from the torus.

Table I-148 - X-210B/X-211B Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP PS NO	1.07
Support	-	-	
X-210B Penetration	25	0.0 ΔP PS NO	1.07
X-211B Penetration	21	DBA CO	1.39
Branch Line	25	0.0 ΔP PS NO	1.16
Valves	21	DBA CO	4.43

X-202A/F Vacuum Relief Line Piping

The calculation reviewed is Penetration X-202A/F R0, "Torus Attached Piping Analysis," July 1983 [7.4.43].

X-202A/F PIPE STRESS REVIEW

Table I-149 - Reported Pipe Stress Results X-202A/F

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	2,936	1.0 S_H = 15,000
1	3	P+N+EQ+SRV	17,857	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	7,827	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	26,710	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	24,869	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	24,812	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.43

Adjusted Pipe Stress Results from X-202A/F

Based on the results from the stress calculation the individual stress contribution for each load condition are in Table I-150:

Table I-150 - Individual Load Condition Contributions per EC X-202A/F

TES TAP	EC (1)	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	2,936	1.0 SH = 15,000	17,100	5.82
1	3	P+N+EQ+SRV	17,857	1.8 SH = 27,000	30,780	1.72
2	16	P+N = 2936 0.0 ΔP PS= 4891	7,827	2.4 SH = 36,000	41,040	5.24
3	21	P+N+EQ +DBA CO	26,710	2.4 SH = 36,000	41,040	1.54
4	25 - 1.7 ΔP	P+N+EQ+SRV = 17857 1.7 ΔP PS= 7012	24,869	2.4 SH = 36,000	41,040	1.65
4	25 – 0.0 ΔP (Accident)	P+N+EQ+SRV = 17857 0.0 ΔP PS= 4891	22,748	2.4 SH = 36,000	41,040	1.80
4	25 – 0.0 ΔP (NO)	P+N+EQ+SRV = 17857 0.0 ΔP PS= 4891 x 1.11	23,286	2.4 SH = 36,000	41,040	1.76
5	27	P+N+EQ+SRV+CH	24,812	2.4 S_H = 36,000	41,040	1.65

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13].
3. S_H the allowable stress value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the maximum 0.0 ΔP Torus External Piping stress and understanding that the maximum Torus Internal Piping stress used for both EC 16 and 25 was 0.0 ΔP, the total EC 21 stress is still the controlling EC.

X-202A/F PIPE SUPPORT REVIEW

The loads for the rigid vertical support at node 30 are not reported. In fact, the calculation for the support H27-8 does not include a Torus Hydrodynamic loading component. This support is outside the torus and the pipe (Top of Torus to VP) straddles the VP bellows. The differential displacement at the VP bellows was adjusted to account for the 0.0 ΔP PS ↑ Upload phase of the event [Attachment G]. The Load Conditions Adjustment Factor is 1.05.

JAF supports were designed to Service Level A Allowable Stress Values. The 0.0 ΔP PS case is listed in Table 5-2 of the PUAAG as Level B [7.2.1]. A commensurate increase in support load would be easily accommodated by the 1.33 increase in the Allowable Stress Value for EC 25. In fact, the maximum support load is reported as 16,200 lbs with a rated capacity of 25,000 lbs [7.4.54Page 21]. Adequate margin exists for 0.0 ∆P NO.

X-202A/F PIPE PENETRATION REVIEW

X-202A Penetration Evaluation

The torus shell penetration X-202A was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Therefore, only EC 21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21 is bounding still applies (Table I-151 to Table I-155). As discussed in Attachment A the Free Shell EC Stress results at the location of maximum P_M and P_L+P_B are unchanged due to 0.0 ∆P NO.

Table I-151 - Reported Penetration Stress Results X-202A

X-202A	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Penetration	18515	$1.5S_{MC}$ = 28,900	33,000	1.78
P_M	Nozzle	14906	$1.0S_{MC}$ = 15,100	17,100	1.15

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported allowable stresses are from 7.4.43 Page 22 and 25 of 43.

Table I-152 - Reported Individual Penetration Loads X-202A

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-419	-190	139	46779	-1729	-2090
TH	173	1190	-339	125000	863	1040
EQ	4420	8670	7040	363230	10880	9650
SRV1	705	5727	1177	23768	1434	1378
CO	17075	4081	7031	168410	10595	14791
CH	3943	728	1739	42965	2282	3830
PS1 (0.0 ∆P) Accident	11330	2267	5140	130560	4873	4500
PS2 (1.7 ∆P)	3524	751	1711	46610	1825	1280

Table I-153 - PS Load Adjusted for 0.0 ∆P Normal Operation X-202A

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ∆P) Accident	11330	2267	5140	130560	4873	4500
PS1 (0.0 ∆P) Normal Operation	12576	2516	5705	144922	5409	4995

Table I-154 - Reported EC Forces and Moments X-202A

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	9660	16505	10434	601742	17188	17988
16	N+TH+0.0 ∆P PS	11922	3647	5618	302339	7465	7630
21	N+TH+SSE+CO	22087	14131	14549	703419	24067	27571
25	N+TH+SSE+SRV+1.7 ∆P PS	9241	16528	10406	605387	16731	15438

Table I-155 - Adjusted EC Forces and Moments X-202A

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	9660	16505	10434	601742	17188	17988
16 (1 & 3)	N+TH+0.0 ∆P PS	12822	3647	5618	302339	7465	7630
21	N+TH+SSE+CO	22087	14131	14549	703419	24067	27571
25 (1, 2 & 3)	N+TH+SSE+SRV+0.0 ∆P PS	13595	11691	9338	563574	13101	12003
EC25 0.0 ∆P PS/EC 21		0.62	0.83	0.64	0.80	0.54	0.44

Table Notes:

1. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].
2. SRSS combination of the dynamic loads was used.

$$\text{EC 25} := |P + DW + TH| + \sqrt{PS^2 + SRV^2 + SSE^2}$$

3. Static loads were combined by signed summation.

Based on a review of the Table I-155- Adjusted Event Combinations – Forces and Moments EC 21 is still the bounding Event Combination for Normal Operation with 0.0 ∆P. Therefore, the penetration stress results remain unchanged and they demonstrate that the Penetration is adequate for continued service at 0.0 ∆P NO.

X-202F Penetration Evaluation

The torus shell penetration X-202F was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

EC 21 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and the maximum free shell stresses. Therefore, only EC 21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 21 is bounding still applies (Table I-156 to Table I-160). As discussed in Attachment A the Free Shell EC Stress results at the location of maximum P_M and P_L+P_B are unchanged due to 0.0 ΔP NO. The vent pipe penetration is isolated from the torus internal loading by the bellows.

Table I-156 - Reported Penetration Stress Results X-202F

X-202F	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/Actual
P_L	Torus Penetration	20382	$1.5S_{MC}$ = 28,900	33,000	1.62
P_M	Nozzle	15715	$1.0S_{MC}$ = 15,100	17,100	1.40

Table Notes:

1. Reconciled allowable stress value is from Section 2.13 Table 11.
2. Reported allowable stress values are from 7.4.43 Page 22 and 25 of 43.

Table I-157 - Reported Individual Penetration Loads X-202F

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	-2730	-1340	-109	-5580	30	-4400
TH	-516	-961	-602	-25300	3510	-3290
EQ	9860	10000	8360	189940	18840	159660
SRV1						
CO	450	2720	6670	156110	5050	18680
CH	270	1216	2520	61780	3490	11270
PS1 (0.0 ΔP) Accident	300	1700	4450	99790	3600	12110
PS2 (1.7 ΔP)	260	1210	2410	60950	3570	10810

Table I-158 - PS Load Adjusted for 0.0 ΔP Normal Operation X-202F

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ΔP) Accident	300	1700	4450	99790	3600	12110
PS1 (0.0 ΔP) Normal Operation	333	1887	4940	110767	3996	13442

Table I-159 - Reported Event Combinations – Forces and Moments X-202F

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	13376	13517	11591	282600	25870	178620
16	N+TH+0.0 ∆P PS	3546	4001	5161	130670	7140	19800
21	N+TH+SSE+CO	13556	15021	15741	376930	27430	186030
25	N+TH+SSE+SRV+1.7 ∆P PS	13366	13511	11481	281770	25950	178160

Table I-160 - Adjusted Event Combinations – Forces and Moments X-202F

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	13376	13517	11591	282600	25870	178620
16	N+TH+0.0 ∆P PS	3579	4188	5651	141647	7536	21132
21	N+TH+SSE+CO	13556	15021	15741	376930	27430	186030
25	N+TH+SSE+SRV+0.0 ∆P PS	13112	12477	10421	250758	22799	167915
EC25 0.0 ∆P PS/EC 21		0.97	0.83	0.66	0.67	0.83	0.90

Table Notes:

1. Penetration X-202F was evaluated as discussed for X-202A

Based on a review of the Table I-160- Adjusted Event Combinations – Forces and Moments EC 21 is still the bounding Event Combination for Normal Operation with 0.0 ∆P. Therefore, the penetration stress results remain unchanged and they demonstrate that the Penetration is adequate for continued service at 0.0 ∆P NO.

X-202A/F BRANCH LINE REVIEW

There are no Brach lines in this problem [7.4.43 Page 1 of 1].

X-202A/F VALVE REVIEW

The maximum stresses for valve VB-1 at Node 70 are shown in Table I-161. The stresses were calculated with the static load plus SRSS of the dynamic load.

Table I-161 - Valves and Pump Stresses X-202A/F

TES TAP	EC	Load Conditions psi	Valve Stress psi	B31.1 Allowable Stress Value psi	Reconciled B31.1 Allowable Stress Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N=2210	2210	1.0 S_H = 15,000	17,100	7.74
1a		P+N+OBE OBE = 8398	10608	1.2 S_H = 18,000	30,780	2.90
1b		P+N+SRV SRV = 878	3088	1.2 S_H = 18,000	41,040	13.29
1c	3	P+N+EQ+SRV EQ = 8436	10692	1.8 S_H = 27,000	41,040	3.84
2	16	P+N+0.0 ΔP PS 0.0 ΔP = 2982	5192	2.4 S_H = 36,000	41,040	7.90
3	21	P+N+EQ+DBA CO DBACO = 4497	11770	2.4 S_H = 36,000	41,040	3.49
4	25	P+N+EQ+SRV+1.7 ΔP PS 1.7 ΔP PS = 1654	10807	2.4 S_H = 36,000	41,040	3.80
4	25 – 0.0 ΔP (Accident)	P+N+EQ+SRV+0.0 ΔP PS 0.0 ΔP PS= 2982	11201	2.4 S_H = 36,000	41,040	3.66
4	25 – 0.0 ΔP (NO)	P+N+EQ+SRV+0.0 ΔP PS 0.0 ΔP PS x 1.11=3310	11315	2.4 S_H = 36,000	41,040	3.63
5	27	P+N+EQ+SRV+Po st CH	10818	2.4 S_H = 36,000	41,040	3.79

Table Notes:

1. Reference: 7.4.43 Pages 1 - 4 of 4.
2. Note that SRV is included with PS2 but not PS1.
3. Original loads were combined by: SRSS combination of the dynamic loads was used.

   EC 25:= $|P + DW + TH| + \sqrt{PS^2 + SRV^2 + SSE^2}$
4. Adjustment for Accident Condition 0.0 ΔP PS ↓ is 1.11 for Normal Operation [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment
5. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Adequate stress margin exists to demonstrate that the valve will perform its design function even using EC 25 0.0 ΔP PS NO pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B.

Table I-162 - X-202A/X-202F Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	21	DBA CO	1.54
Support	-	-	
X-202A Penetration	21	DBA CO	1.15
X-202F Penetration	21	DBA CO	1.40
Branch Line	-	-	
Valves	21	DBA CO	3.49

X-225A & B RHR Pump Suction Piping

Calculation A384.F02-12 Rev 4 provides the ECCS RHR Suction Strainer results based on the 2018 Modification performed under EC 622508 as discussed in Section 2.17 [7.4.63]. The calculation performed developed changes to the Torus Internal portion of the two RHR trains which include the Submerged Strainer with Ramshead, attached Bellows and Piping up to and including the Torus Penetration.

This Attachment includes changes as a result of 0.0 ΔP NO. In addition it should be noted that the TES X-225 A & B Torus Attached piping calculations are still valid for the external piping and supports [7.4.80 & 7.4.81].

The modification performed during the 2018 refueling outage added strainer clamshell modules to protect the strainer assembly from the RHR Discharge Piping Jet Load. It also considered the Jet Load from the RHR return flow. The RHR return line flow will not occur until the PS fallback has been completed (i.e., the end of the PS event) as the pool is the RHR pump suction supply.

Service Level D forces, moments and stress results performed herein to address the PS 0.0ΔP NO for the RHR system have been recalculated based on the discussion in Section 2.17.3 that address PS Inertia together with Vent Clearing Loads. PS Fallback is addressed independently from the PS Inertia load conditions since timing does not support PS Inertia and Fallback occurring simultaneously.

X-225A & B PIPE STRESS REVIEW

A384.F02-12, reports the maximum Service Level D stress in Table 13.1.-1 as 31092 psi. Attachment K to this calculation evaluates the addition of the clamshell and RHR Discharge Piping Jet Load. The stress added is 257 psi (Att. K Page 18 of 20). The maximum Service Level D stress was not controlled by the evaluated PS 1.7ΔP NO case.

Table I-163 - X-225 A&B Summary of A384.F02-12 Reported Stress Results for ECCS Suction Strainer Piping to the Penetration

Load Condition	Fx (lbs)	Fy (lbs)	Fz (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS Moments (in-lbs)	Stress (psi)
DW	-6	702	-34	-19243	4407	142926	144283	1,048
P								1,800
CS (Clamshell)								257
SSE	1402	186	648	8242	103706	44337		
SRV	1427	224	2702	7749	266221	65083		
1.7ΔP PS NO Inertia	889	2111	1411	54268	310303	726603		
PST (FB + 1.7ΔP NO Inertia)	5184	6944	6878	354299	1788789	2271100		
VCL	4295	2550	2943	39497	1478486	462236		
SRSS (PST, SRV, SSE)	5557	6950	7418	354480	1811462	2272465	2927652	21,262

Load Condition	Fx (lbs)	Fy (lbs)	Fz (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS Moments (in-lbs)	Stress (psi)
Total DW+P+CS+SRSS (PST, SRV, SSE)								24,110
0.0 ΔP PS NO Inertia	2276	5404	3612	138926	794376	1860104		
PST1 (0.0 ΔP PS NO Inertia + VCL)	6571	7954	6555	178423	2272862	2322340		
SRSS (PS FB, SRV, SSE)	4738	4842	6133	300244	1505838	1546503	2179305	15,827
SRSS (PST1, SRV, SSE)	6869	7959	7120	178781	2290749	2323674	3267867	23,733
Total DW+P+CS+SRSS (0.0 ΔP PST, SRV, SSE)								26,581

Table Notes:

1. Information is included from Table 13.1-1 Maximum Piping Stresses and the associated information provided in Attachment G of A384.F02-12 [7.4.63].
2. PS 0.0 ΔP NO = 2.56 x PS 1.7ΔP NO. The Load Condition Adjustment Factors are provided in Section 5.1.
3. PS Inertia is the result of Torus Shell Motion on the internal and external portions of the piping system.
4. PST is the sum of the Inertia plus Internal PS Load Conditions occurring simultaneously on the submerged ECCS Suction Strainer.
5. VCL are vent clearing loads on the submerged portion of the ECCS Suction Strainer
6. FB are the PS fallback loads
7. Reconciled stress allowable is 2.4 S_H = 2.4 x 17,100 = 41,040 psi [Section 2.13]
8. Total Stress due to 0.0ΔP NO = 26,581 psi < 31,092 + 257 = 31,349 psi
9. Interaction ratio = 41040/ 31,349 = 1.31

Table I-164 - X-225 B Summary of TES Reported Stress Results for External Piping to the Penetration

TES TAP	EC	Load Conditions	Pipe Stress (psi)	B31.1 Allowable Stress Value (psi)	Reconciled Allowable Stress Value (psi)	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	6,596	1.0 SH = 15,000	17,100	2.59
1	3	P+N+SRV+EQ	25,176	1.8 SH = 27,000	30,780	1.63
2	16	P+N+0.0 ΔP PS	29,671	2.4 SH = 36,000	41,040	1.38
3	21	P+N+EQ+DBA CO	35,643	2.4 SH = 36,000	41,040	1.15
4	25 – 1.7 ΔP NO	P+N+EQ+SRV +1.7 ΔP PS	34,386	2.4 SH = 36,000	41,040	1.19
4	25 – 0.0 ΔP NO	P+N+SRSS (EQ, SRV, 0.0 ΔP PS)	34740	2.4 SH = 36,000	41,040	1.18
5	27	P+N+EQ+SRV+ CH	31282	2.4 S_H = 36,000	41,040	1.31

Table Notes:

1. Stress Results taken from bounding X-225B train which has the maximum stress values for all ECs as compared to X-225A [7.4.80 & 7.4.81].
2. There are individual worksheets included in the TES X-225A and X-225B calculation packages that contain the individual load conditions for the ECs.

The limiting interaction ratio of 1.15 is based on the TES X-225 B external piping. The internal pipe stress values are from the A384.F02-12 Table 13.1-1 are not more limiting.

X-225 A&B PIPE PENETRATION REVIEW

The internal ECCS suction strainer bellows act to partially isolate the strainer assembly from the associated Torus Penetrations (X-225 A&B) for the purposes of the Penetration evaluation.

Therefore, the 2018 Update to the ECCS Suction Strainers to add clamshells which increase local strainer weight and add the additional drag due to the RHR Jet load will have negligible effect on the penetrations that are protected from these load conditions by the bellows.

The penetration results from the previous revisions demonstrate considerable margin with respect to the allowable stress values. The torus internal load condition evaluation provided in A384.F02-12 has been updated to account for the fact that PS Inertia is complete prior to initiation of the PS fallback loads (Section 2.17.3]. PS Inertia and Vent Clearing Loads are simultaneous.

The following table recombines the torus internal loads as discussed above using the local coordinate system from the piping analysis.

Table I-165 - Reported Penetration Forces and Moments from the Torus Internal ECCS Suction Strainer Piping Evaluation - X-225 A&B

Load Condition	Axial (lbs)	Fy (lbs)	Fz (lbs)	Torsional (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS Forces (lbs)	SRSS Moments (in-lbs)
PS 1.7 ΔP NO Inertia	67	1964	159	38545	4900	60454		
PST (PS Inertia + FB)	2151	5891	4239	87961	130370	150923	7570	217971
VCL	390	2270	340	11388	11683	56183		
PS 0.0 ΔP NO Inertia	172	5028	407	98675	12544	154762		
PS FB	2084	3927	4080	49416	125470	90469	6034	162386
PST1 (0.0 ΔP NO Inertia +VCL)	562	7298	747	110063	24227	210945	7357	239163
Max (PS FB, PST1)/PST							0.97	1.10

Table Notes

1. Information is included from Section 13.7 Penetration Load Evaluation and the associated information provided in Attachment G of A384.F02-12 [7.4.63].
2. PS 0.0 ΔP NO = 2.56 x PS 1.7ΔP NO. The Load Condition Adjustment Factors are provided in Section 5.1.
3. PS Inertia is the result of Torus Shell Motion on the internal and external portions of the piping system.
4. PST is the sum of the Inertia plus Internal PS Load Conditions occurring simultaneously on the ECCS Suction Strainer.
5. VCL are vent clearing loads on the submerged portion of the ECCS Suction Strainer
6. FB are the PS fallback loads
7. Internal PS 0.0 ΔP NO Loads are 1.10 x PS 1.7 ΔP NO

Table I-166 - Reported Penetration Torus Internal and External Forces and Moments A384.F02-12 ECCS Suction Strainer Piping Evaluation - X-225 A&B

LC	Fx o (lbs)	Fx i (lbs)	Fy o (lbs)	Fy i (lbs)	Fz o (lbs)	Fz i (lbs)	Mx o (in-lbs)	Mx i (in-lbs)	My o (in-lbs)	My i (in-lbs)	Mz o (in-lbs)	Mz i (in-lbs)
DW	3429	374	2783	781	1097	6	140148	3676	11424	206	16092	10198
TH	3595	82	2893	46	7125	815	181944	3072	78312	25065	27948	1399
SSE	3103	264	7951	283	1971	1297	234528	5165	36276	34292	71016	5304
PS	12956	2151	5210	5891	1122	4239	95681	87961	5443	130370	25824	150923
SRV	3296	329	1680	552	542	2048	31879	8271	1858	63024	3762	14264
PS x Factors	14381	2366	5783	6480	1245	4663	106206	96757	6042	143407	28665	166015
Summation of O+I	Fx		Fy		Fz		Mx		My		Mz	
DW Sum	3803		3564		1103		143824		11630		26290	
TH Sum	3677		2939		7940		185016		103377		29347	
SSE Sum	3367		8234		3268		239693		70568		76320	
PS x Factor Sum	16747		12263		5908		202963		149449		194680	
SRV Sum	3625		2232		2590		40150		64882		18026	
Calculated	24943		21442		16275		645477		292558		265518	
SRSS (Fs & Ms)			36698						756789			
Maximum Reported Envelop	24502		20503		15835		633453		282882		249000	
SRSS (F, M)			35658						737079			
Calculated/ Reported IR			1.03						1.03			

Table Notes:

1. A384.F02-12 Section 13.7 reported loads for Penetrations X-225 B and X-225 A. X-225 B loads clearly bound X-225 A.
2. o – Torus outside loads. These are the TES calculated penetration loads from Calculation Packages X-225 A&B.
3. i – Torus inside loads. These are the latest loads from the strainer.
4. A Load Condition Adjustment Factor of 1.11 per Section 5.1 was used for the Torus outside PS stress results.

5. A Load Condition Adjustment Factor of 1.10 from the previous table was used for the Torus inside PS stress results.

Table I-167 – Maximum Reported Penetration Stress Results - X-225 A&B

X-225 A&B	Penetration Location	Stress (psi) x 1.03	Reported Allowable (psi)	Reconciled (psi)	Allowable/ Actual
P_L	Torus Shell at Nozzle	18556	$1.5S_{MC}$ = 28,900	33,000	1.78
P_L	Torus Shell at Reinforcing Pad	22834	$1.5S_{MC}$ = 28,900	33,000	1.45
P_M	Nozzle	14127	$1.0S_{MC}$ = 19,300	22,000	1.56

Table Notes:

1. Stress Results were factored by 1.03 based on the previous table results.
2. Reconciled allowable stress is from Section 2.13 Table 11.
3. Reported stresses were from 7.4.36 Pages 28 and 31 of 83.

The maximum reported Penetration Stress Results for RHR ECCS Suction Strainer Penetrations X-225 A & B have adequate margin for 0.0 ΔP NO with an Allowable/Actual Ratio = 1.45.

X-225 A&B ECCS SUCTION STRAINER FLANGE REVIEW

The ECCS Suction Strainer flange forces and moments are tabulated in Section 13.2 of A384.F02-12 [7.4.63]. Inspection of the individual results in Attachment B of the report indicates that the controlling flange locations for the three flange types are at Nodes 280, 140 and BELR1 for the PS Event Combination. The local direction load condition forces and moments were extracted directly from the Attachment G computer output and they are tabulated below.

Tables I-168 – Maximum Reported ECCS Suction Strainer Flange Resultant Moments - X-225 A&B

Node	EC/LC	Faxial (lbs)	Mtorsion (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS (My, Mz) (In-lbs)
140	DW	-6	-19,243	4,407	142,926	
	TE	-5,521	755	5,589	-6,145	
	SSE	1441	8242	103706	44337	
	SRV	1509	7749	266221	65083	
	PST	5184	354299	1788789	2271100	
	VCL	4295	39497	1478486	462296	
	PSI DP=1.7	889	54268	310303	726603	
	PSI DP=0.0 NO	2276	138926	794376	1860104	
	FS FB = PST-PSI DP=1.7	4295	300031	1478486	1544497	
	PS FB	4775	300244	1505838	1546503	
	PSI+VCL DP=0.0 NO	6894	178781	2290749	2323734	
	DW+TE+ SRSS (PS FB, SRV, SSE)	10302	319487	1515834	1689429	2269785
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	12421	198024	2300745	2466660	3373105
	Reported Maximum	13383	290057	2725319	2913735	3989638

Node	EC/LC	Faxial (lbs)	Mtorsion (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS (My, Mz) (In-lbs)
280	DW	3	26250	-284	150511	
	TE	-5403	-4	25394	1249	
	SSE	1227	9604	141043	60434	
	SRV	1249	4062	734817	58458	
	PST	26695	411477	1656911	3091501	
	VCL	25900	51786	983018	345002	
	PSI DP=1.7	796	64486	319901	944444	
	PSI DP=0.0 NO	2038	165084	818947	2417777	
	FS FB = PST-PSI DP=1.7	25899	346991	1337010	2147057	
	PS FB	25958	347148	1532137	2148703	
	PSI+VCL DP=0.0 NO	27993	217121	1951134	2764058	
	DW+TE+ SRSS (PS FB, SRV, SSE)	31358	373398	1557247	2300463	2777976
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	33393	243371	1976244	2915818	3522433
	Reported Maximum	11775	278823	2659735	2775715	3844318

Node	EC/LC	Faxial (lbs)	Mtorsion (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS (My, Mz) (In-lbs)
BELR1	DW	-102	3676	117	-2699	
	TE	-82	-3071	13863	-773	
	SSE	129	5165	17503	2046	
	SRV	329	8270	34861	6677	
	PST	2151	87959	72088	69921	
	VCL	390	11388	7014	24974	
	PSI DP=1.7	67	5165	17503	2046	
	PSI DP=0.0 NO	172	98675	6953	85627	
	FS FB = PST-PSI DP=1.7	2084	49414	69372	36473	
	PS FB	2114	50367	79587	37136	
	PSI+VCL DP=0.0 NO	663	110494	41433	110821	
	DW+TE+ SRSS (PS FB, SRV, SSE)	2298	54043	93567	40608	101999
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	847	114170	55413	114293	127018
	Reported Maximum	2304	103707	103561	76909	128996

Table Notes:

1. Event Combinations are as described in Section 13.2 of A384.F02-12 [7.4.63]
2. The Axial Force reported was selected for the Node and Event Combination with the bounding SRSS moment summary as the moment resultant is the primary parameter for the flange evaluation.

   In the case of Node 280, the DW+TE +SRSS (SRV, SSE, PS) calculated Axial Force was 32,149 versus the current 33,393 lbs an approximate a 4% increase. The Axial Force (11,775 lbs) and SRSS moment summary reported was for Event Combination DW+TE +SRSS (SSE, CO).

   The axial force contribution from 33,393 lbs is on the order of 1500 psi for a 20 NPS pipe size which is less than of 4% of the allowable stress and considered negligible with respect to the result.
3. PST = PS Inertia + PS FB

4. PS Inertia and VCL are combined. PS FB will not occur with PS Inertia per Section 2.17.3.
5. PS dP 0.0 NO = PSI dP 1.7 x 2.56. The Load Condition Adjustment Factors are provided in Section 5.1.
6. PS is not the controlling case for these flanges. The resultant (SRSS) flange moment is less than previously reported for the three bounding locations and therefore the flanges are acceptable for continued service at PS 0.0 ΔP NO.

X-225 A&B ECCS SUCTION STRAINER BELLOWS REVIEW

The Bellows qualification in A384.F02-12 Section 13.3 is based on a fatigue evaluation [7.4.63]. PS is not considered for this evaluation in accordance with the Structural Acceptance Criteria Table 5-2 Note 5 that specifically excludes the PS loading from fatigue requirements due to its short duration [7.2.1]. The bellows remains qualified for 0.0ΔP NO.

X-225 A&B ECCS SUCTION STRAINER CORE TUBE REVIEW

The ECCS Suction Strainer Core Tube forces and moments are tabulated in Section 13.4 of A384.F02-12 [7.4.63]. Inspection of the individual results in Attachment B of the report indicates that the controlling core tube location for the three sections is at Node 295 for the PS Event Combination. The local direction load condition forces and moments were extracted directly from the Attachment G computer output and they are tabulated below.

Table I-169 – Maximum ECCS Suction Strainer Core Tube Resultant Moments - X-225 A&B

Node	EC/LC	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)	SRSS (Mx, My, Mz) (in-lbs)
295	DW	3	752	2	26242	-249	150429	
	TE	-5403	8	-29	-4	24830	1087	
	SSE	1401	58	292	9600	150622	63142	
	SRV	1486	191	2514	4060	782392	56999	
	PST	26688	8270	8735	411321	1796967	3233978	
	VCL	25899	4334	8150	51797	1140764	343952	
	PSI DP=1.7	789	1978	670	64440	332497	948204	
	PSI DP=0.0 NO	2020	5064	1715	164966	851192	2427402	
	PS FB = PST-PSI DP=1.7	25899	6292	8065	346881	1464470	2285774	
	PS FB	25979	6295	8453	347038	1667182	2287356	
	PSI+VCL DP=0.0 NO	27993	9400	10185	217014	2145394	2772659	
	DW+TE+ SRSS (PS FB, SRV, SSE)	31379	7055	8480	373280	1691763	2438872	2991571
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	33393	10160	10212	243256	2169975	2924175	3649488
	Reported Maximum	13268	22018	19544	290057	2704655	2886585	3966316

Table Notes:

1. Event Combinations are as described in Section 13.4 of A384.F02-12 [7.4.63]
2. The Axial Force reported was selected for the Node and Event Combination with the bounding SRSS moment summary as the moment resultant is the primary parameter for the core tube evaluation.

   In the case of Node 295, the DW+TE +SRSS (SRV, SSE, PS) calculated Axial Force was 32,158 versus the current 33,393 lbs an approximate a 4% increase. The Axial Force (13268 lbs) and SRSS moment summary reported was for Node 150 Event Combination DW+TE +SRSS (SSE, CO).

The axial force contribution from 33,393 lbs is on the order of 1500 psi for a 20 NPS pipe size which is less than of 4% of the allowable stress and considered negligible with respect to the result.

3. PST = PS Inertia + PS FB
4. PS Inertia and VCL are combined. PS FB will not occur with PS Inertia per Section 2.17.3.
5. 0.0 ΔP PS NO = 1.7 ΔP PS NO x 2.56. The Load Condition Adjustment Factors are provided in Section 5.1.

The ECCS Suction Strainer Core Tube accelerations are tabulated in Section 13.5 of A384.F02-12 [7.4.63]. Inspection of the individual results in Attachment E of the report provides the controlling Service Level D Event Combination for the 5 strainer modules. The controlling dynamic event combinations are a result of the CO or CH load conditions.

Table I-170 – Maximum ECCS Suction Strainer Core Tube Accelerations - X-225 A&B

Service Level D Accelerations (g's)	Vertical	Horizontal	Lateral
Maximum Reported	11.23	7.59	12.31
SRSS (PST, SRV, SSE)	1.58	0.76	1.75
2.56 x SRSS	4.04	1.95	4.48

Table Notes:

1. The full SRSS results are conservatively multiplied by the applicable PS Adjustment Factor (2.56) based on Section 5.1.

Review of the summarized results demonstrates adequate margin for 0.0ΔP NO. Addendum K12 also contains acceleration values as a result of the clamshell that have been reviewed and they are acceptable.

X-225 A&B ECCS SUCTION STRAINER SUPPORT REVIEW

The ECCS Suction Strainer Support Loads Evaluation is tabulated in Section 13.8 of A384.F02-12 [7.4.63]. These supports are at nodes 220, 350 and 520 in the piping model. The following Table summarizes the load conditions and calculates the PS Event Combinations with consideration that PS FB does not occur with PS Inertia loading. It also calculates the PS Event Combinations for PS Inertia plus VCL load conditions. This change is discussed in Section 2.17.3 of this report. Critical support load combinations are provided in A384.F02-12 Table 13.8-2. Attachment G provides the results of individual load conditions at these supports and it also summarizes Event Combinations. Attachment K provides the added support loads due to the Clamshell Modification including the RHR Jet Load.

The following table provides the support results for the three nodes listed:

Table I-171 – ECCS Suction Strainer Support Load Summary - X-225 A&B

Node	EC/LC	F1 (lbf)	F2 (lbf)	
S2-220	DW	6295	-4785	
	TE	789	1103	
	SSE	5376	6534	
	SRV	-18439	-24033	
	PS FB	103332	103094	
	VCL	66889	72734	
	PSI 1.7DP	8303	12067	
	PSI 0.0 DP NO	21256	30892	
	PSI+VCL DP=0.0 NO	88145	103626	
	DW+TE+ SRSS (PS FB, SRV, SSE)	112186	110845	
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	97297	111361	
	Reported Maximum	120805	122806	Average
	Maximum/ Reported	0.93	0.91	0.92

Node	EC/LC	F1 (lbf)	F2 (lbf)	M3 (in-lbs)	
S3-350	DW	2140	-1645	-16533	
	TE	453	581	26	
	SSE	1879	2289	6128	
	SRV	-7225	-9388	1282	
	PS FB	36991	36734	226559	
	VCL	16531	18661	40296	
	PSI 1.7DP	6611	9702	23836	
	PSI 0.0 DP NO	16924	24837	61020	
	PSI+VCL DP=0.0 NO	33455	43498	101316	
	DW+TE+ SRSS (PS FB, SRV, SSE)	40330	39629	243178	
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	36871	46204	118042	
	Reported Maximum	47118	49169	267023	Average
	Maximum/ Reported	0.86	0.94	0.91	0.90

Node	EC/LC	F1 (lbf)	F2 (lbf)	M3 (in-lbs)	
S1-520	DW	3524	-2664	21023	
	TE	395	537	127	
	SSE	2673	3173	7499	
	SRV	-6251	-7895	-2481	
	PS FB	46521	43476	273584	
	VCL	46521	32636	61752	
	PSI 1.7DP	4336	5540	42262	
	PSI 0.0 DP NO	11100	14182	108191	
	PSI+VCL DP=0.0 NO	57621	46818	169943	
	DW+TE+ SRSS (PS FB, SRV, SSE)	50934	46965	294848	
	DW+TE+ SRSS (PSI + VCL, SRV, SSE)	61940	50249	191276	
	Reported Maximum	54976	51700	337083	Average
	Reported/ Maximum	1.13	0.97	0.87	0.99

The average support loads have not increased. Therefore, the support calculations as modified by the additional loads from Attachment K are still applicable.

X-225 A&B ECCS SUCTION STRAINER REVIEW OF LOCAL LOADS ON THE TORUS RING GIRDER AND SHELL

The Local Loads from ECCS Suction Strainer Support are addressed in Section 4 of A384.F02-15 [7.4.64]. These supports are at RHR nodes 220, 350 and 520 and CS node 600 in the respective piping models. Support loads at these locations have not increased as a result of 0.0ΔP NO.

As a part of this calculation package a more refined ANSYS 1/32nd model was prepared and additional gussets added to the Ring Girder. Results used were from the original TES calculations. Refinements made using the 1/16th model to evaluate these components are conservatively not reflected in this calculation.

To facilitate completion of this project the refinements may not be incorporated where adequate margin exists. However, the reconciled allowable stress values will be used as discussed in Sections 2.13 and 2.14 of the TR.

Ring Girder Flange

The ring girder flange results are reported in Section 4.7.1 Table 4.7.1A of the calculation. Controlling results and IR are at the RG Flange.

The "existing" SI values for the flange are from the TES evaluation and consistent with those reported in Attachment C of the TR. They are for 0.0 ΔP PS but have not been increased by the 1.11 Load Condition Adjustment Factor from Section 5.1 for NO of the TR.

RG Flange (1):

PL = 20.38 + 1.11 x 8.28 = 29.57 < 1.5Smc = 1.5 x 22 = 33 ksi. Therefore, IR = 0.90

RG Flange (2):

PL = 20.49 + 1.11 x 5.84 = 26.97 < 1.5Smc = 1.5 x 22 = 33 ksi. Therefore, IR = 0.82 (See 4.7.2)

Ring Girder to Torus Shell Weld

It should be noted that Section 4.74 of the calculation has a unit discrepancy. The units on Table 4.7.3 are annotated as lb/in. The recalculated values at the bottom of Section 4.7.4 are listed as psi. It is clear that the weld stress intensities are in lb/in units. The Load Combination discussion in Section 4.3 provides an analytical strategy with the following facts:

- PS FB is the dominant load
- PS 1.7 and 0.0 ΔP are about the same load intensity

In addition, it has been demonstrated that the RHR and CS Support Loads have not increased for 0.0ΔP NO. Therefore, a Load Condition Adjustment Factor need not used for this evaluation as the PS FB factor is 1.0.

As discussed above the support loads have not increased for 0.0 ΔP NO further supporting that no adjustment factor is required.

The reported load is from the TES calculation and represents a maximum stress intensity including peak stress from the geometry configuration at the columns. The reported maximum stress intensity in Tables C-7 and C-8 in Attachment C is 7.36 k/in from the 1/16th Model which more accurately models the column to shell configuration with all gussets.

This TR will use the following IR for the RG to Shell Weld:

RG to Shell Weld:

10.354+1.09 x 5.908 = 16.8 k/in < 2.2 t_w 1.5 PM = 2.2 x 5/16 x 1.5 x 22 = 22.7 k/in. IR = 0.74

Note: The allowable weld stress intensity is taken from Section 4.3 of the calculation. This is consistent with the original Mk I Program methodology.

Torus Shell Stress

The calculation uses torus shell stress results from the TES calculation which are conservative because the bounding ECs are for the CO Load Condition. It is noted for completeness that there is additional margin that can be recovered as the torus internal loads are a result of the dominate PS FB loading which does not combine with CO.

The calculation provided the following stress values. This TR is using the reconciled allowable stresses as discussed above:

SI (P_M) =16.37 +1.09 x 1.46 x (0.451/0.532) = 17.72 ksi < S_{MC} = 22 ksi. IR = 0.81

SI (P_L) = 10.46+ 1.09 x 5.6 = 16.56 ksi < 1.5 x S_{MC} = 33 ksi. IR = 0.50

SI (P_M + P_B) = 16.80 +1.09 x 9.9 = 27.68 ksi < 1.5 x S_{MC} = 33 ksi. IR = 0.84

SI (Range) = 38.81 + 1.09 x (2 x 9.9) = 60.39 ksi < 3.0 x S_{M1} = 69.9 ksi. IR = 0.86

Note: The Range is not a consideration for the PS event. When considering the 0.0 ∆P PS NO stress results in Attachment A:

P_M = 11.00 vs 13.78 ksi

P_M + P_B = 11.02 vs 14.15 ksi

Base Plates, Gusset Plates and Associated Welds

The ECCS Suction Strainer items are addressed in Section 4.10 of the calculation. Since the 0.0∆P NO loads on the supports do not increase the reported interaction values will not change.

Base Plate Weld Stress IR = 0.66 ksi

Thick Base Plate = 28.78 ksi < 1.5 S_{MC} = 33.0 ksi IR = 0.87

Flange Cover Plate = 0.56

X-225 A&B ECCS SUCTION STRAINER REVIEW OF SUPPORT EVALUATIONS

The torus internal supports for the ECCS suction strainers are addressed in A384.F02-16 and 17 [7.4.65 and 7.4.66]. Calculation A384.F02-16 addresses support configuration S2 and A384.F02-17 addresses support configurations S1 and S3. These supports are at RHR nodes 220, 350 and 520 and CS node 600 in the respective piping models. Support loads at these locations have not increased as a result of 0.0∆P NO.

The S1/S3 configuration was previously addressed for the CS ECCS Suction Strainer at Node 600 in the Support Interaction Ratio Summary Tables for both X-227A and X-227B. The maximum IR for both RHR and CS ECCS Suction Strainers was evaluated using 0.0 ∆P NO: IR = 0.93.

The IR for the S2 configuration for the RHR ECCS Suction Strainers was reported in Section 11.0 Summary as: IR = 0.93.

X-225 A&B ECCS SUCTION STRAINER REVIEW CLAMSHELL DESIGN

The clamshell design for the strainer is reviewed in A384.F02-19 [7.4.67]. Attachment E of the document contains the updated strainer and perforated plate evaluation for the clamshell design. The evaluation included both the clamshell protected and unprotected plate. The maximum IR for the Clamshell Design is reported in Section E 7.0 Conclusions: IR = 0.93. This IR is also reported in Section 10 Results. The Section 10 results also report a maximum IR = 0.94 for the perforated plate. However, this IR appears to be superseded by the Attachment E evaluation. It is noted that the Allowable Stress Values used are not the reconciled values. Per Section 5.1 of the calculation the material is A240 Tp 304 and S_H used in the calculation was 17.56 ksi. The S_H = 20 ksi per Section 2.13 for the reconciled material properties. The adjusted IR = 0.83 with consideration of the next most limiting IR listed.

X-225 A&B RHR EXTERNAL PIPING DESIGN

The TES X-225A and X-225 B calculation packages addressed the external piping analysis results for the two RHR trains [7.4.80 & 7.4.81]. The torus external piping was considered isolated from the torus internal piping by the bellows for the purposes of evaluating the ECCS Suction Strainer Upgrade Design and Clamshell modification that replaced the original strainer used in the TES analysis. Based on a comparison of the as-built piping configuration from the penetration to the upgraded strainer bellows and the original strainer design the internal loads analyzed by TES would be conservative.

RHR Pump Nozzles

The RHR pump nozzle information provided in the two TES X-225 A&B calculation packages summed the static and dynamic load conditions to determine nozzle loads. A representative example is provided below which sums the static loads with the SRSS of the dynamic loads as is appropriate.

Table I-172 – RHR Pump Load Summary - X-225 A&B

RHR Pump 10P-3B	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)
DW	1617	417	-302	-53676	-29940	-5976
TH	28591	2743	5806	28440	531504	114000
SSE	4765	8599	7024	640176	136668	779412
SRV	590	1040	1480	81910	32170	35370
PS1 0.0ΔP Accident (Inertia)	2587	12035	4812	1016453	213216	387753
PS Internal	1767	10575	3882	881863	159086	337403
PS1 0.0ΔP NO	2872	13359	5341	1128263	236670	430406
DW+TH+SSE+SRV	35563	12799	14008	696850	670402	922806
DW+TH+PS 0.0 ΔP NO	32795	15195	10316	991217	714780	495777
DW+TH+PS 0.0ΔPNO+SSE+SRV	37330	23374	17890	1578713	829488	1260209
DW+TH+SRSS (PS 0.0 ΔP NO, SSE, SRV)	35803	19081	14451	1274576	776747	999081

Table Notes:

1. The TES reported Event Combinations conservatively summed all Load Conditions.
2. The PS external (Inertia) load is: PS1 0.0ΔP NO = 1.11 x PS1 0.0ΔP Accident per Load Condition Adjustment Factors from Section 5.1.
3. The new PS Event Combination added the static loads to the SRSS of the dynamic loads.
4. PS Internal and PS external loads are summed to determine the total PS contribution.
5. The average load reduction of the force and moment contributions for the Pump Nozzle is a factor of 0.85.

Based on review of the Event Combinations in the table above, TES previously calculated pump loads are bounding and therefore the RHR Pumps are adequate for 0.0ΔP PS NO.

RHR Branch Lines

The RHR branch line information provided in the two TES X-225 A&B calculation packages summed the static and dynamic load conditions to determine nozzle loads. The branch line summary provided below sums the static loads with the SRSS of the dynamic loads as is appropriate for 0.0ΔP NO.

Table I-173 –RHR Branch Line Summary - X-225 A&B

Node/ (Train)	Descriptions	DW (psi)	SLP (psi)	PS1 (psi)	PS2 (psi)	PS internal (psi)	SSE (psi)	EC 1.7ΔP NO (psi)	EC 0.0ΔP NO (psi)
Node 32 (A)	1 1/2" Drain	966	763	2809	2342	5900	3669	13640	11465
Node 45 (B)	1 1/2" Drain	753	763	1612	1648	11314	4669	19147	15426
Node 40 (B)	1 1/2" W20-152-46B	1604	763	5046	5843	16139	8167	32516	25590
Node 175 (B)	1" W20-152-45B	2572	1485	1102	682	375	3551	8665	7951
Node 220 (B)	1 1/2" W20-152-124B	1240	629	1514	1612	5342	3307	12130	9631

Table Notes:

1. PS1 = 0.0ΔP Accident
2. PS2 = 1.7ΔP NO
3. EC 1.7ΔP NO = DW+SLP+PS2+PS Internal+SSE
4. 0.0ΔP NO = 1.11 x PS1 per Load Condition Adjustment Factors from Section 5.1.
5. EC 0.0ΔP NO = DW+SLP+SRSS ((0.0ΔP NO +PS Internal), SSE)

Based on review of the Event Combinations in the table above, TES previously calculated branch line stresses are bounding and therefore the branch lines are adequate for 0.0ΔP PS NO. The Allowable/ Actual Pipe Stress is 2.4 S_H = 41,040 psi/25,590 psi = 1.60.

RHR Motor Operated Valve and Pump Nozzle Stress and Acceleration Review

Valve stresses are reported as significantly less than 1.2S_H = 18,000 psi. The reconciled allowable is 20,520 psi. The maximum reported valve stress from X225A&B is less than 7500 psi. There is adequate margin available to accommodate 0.0ΔP PS NO. Based on the Summary of TES Reported Stress Results for External Piping to the Penetration the maximum EC 25 PS stress values increased from 34,386 to 34740 psi or 1%.

The maximum reported valve accelerations are given below:

- MOV-13A 2.4/ 2.1 Controlled by DBA CO
- MOV 151B 1.6/.8 Controlled by DBA CO

Based on are review of these tow valves the PS1 (0.0ΔP Accident) acceleration are approximately 60% of the DBA CO accelerations. The Load Condition Adjustment Factor from Section 5.1 is 1.11. Based on review of the Pump and Valve stress and acceleration the RHR Pumps and associated Motor Operated Valves are adequate for 0.0ΔP PS NO.

RHR Supports

The RHR Supports were evaluated by TES for the loads developed during preparation of the X-225 A & B calculation packages [7.4.80 & 7.4.81]. That is, the support loads were developed using the torus internal Load Conditions from the original suction strainer evaluation. The external piping and supports were not reanalyzed as a part of the A384.F02-12 ECCS Suction Strainer upgrade [7.4.63]. The upgrade added a bellows between the X-225 torus penetrations and the upgraded strainer significantly reducing the penetration loads from the new strainer submerged structure load conditions. The Table I-174 below provides the results. The forces are reported in Table I-174 are consistent with the support analysis to be reviewed. The Table demonstrates that the new ECCS Suction Strainer design with the Bellows reduces load at the penetration by a factor of 0.20. The internal loads from the TES support calculations will be reduced by an adjustment factor of 0,20 based on the results in Table I-174.

The torus penetration is the driver for the piping loads due to Pool Swell Inertia and it is also the location for load transfer for the internal submerged structure load conditions. The Inertia and Internal PS support loads will attenuate with distance from the penetration. Therefore, those supports nearest the penetration will be reviewed. Pump nozzles are acceptable based on the results given above.

TES Support Load Conservatisms

- The support analysis performed by TES generally summed the loads unless there was a specific calculation in the support package recombining them using SRSS of the Dynamic Load Conditions.
- Based on a review of Support Load Summary 5321-Loads it appears that the maximum external load is reported for each support [7.4.94]. Therefore, the maximum external load is not necessarily from the PS load condition. However, when the maximum external load is taken from a PS load condition it would be the larger of the 1.7 ΔP or 0.0 ΔP. This package was prepared as a screening criterion to determine which supports required reanalysis for Mk I ECs. Therefore, the PS External Load Adjustment Factor for 0.0 ΔP PS Accident to NO from Section 5.1 is 1.11.
- The internal loads were calculated for 0.0ΔP only for both the TES and strainer upgrade evaluations.
- The support calculation packages prepared by TES used normal operation allowable stress values (i.e., Service Level A). The PS Event Combinations are Service Level D for the piping and supports per the Structural Acceptance Criteria Table 5-2 [7.2.1]. This is a factor of at least 1.5 on the Service Level A allowable stress values.
- The referenced snubber catalog provides the Design Rated Load and the Faulted Load [7.5.13]. The faulted load is a factor of 1.5 higher. The support calculations all conservatively used the Design Rated snubber load.
- Table I-174 below indicates that the submerged structure torus internal PS Event Combinations used by TES are overly conservative for the new ECCS Suction Strainer design with the in-line Bellows. The load reduction factor of 0.20 shall be used for internal submerged structure loads for the updated TES analysis to demonstrate acceptability of 0.0 ΔP NO based on the upgraded strainer design.

Table I-174 –ECCS Suction Strainer Submerged Loads Comparison - X-225 A&B

Node	Location	FX (lbf)	FY (lbf)	FZ (lbf)	SRSS (FX, FY, FZ)
10 TES	X-225 A	14940	38370	2280	41239
10 TES	X-225-B	2915	2843	38260	38476
X225 Upgrade	Typical	2151	5891	4239	7570

Table Notes:

1. The forces were SRSS'd due to differences in local directions at the two TES penetrations. The forces for the strainer upgrade are on average 20% (i.e., a factor of 5.1) of those from the TES calculations.

Support Calculation Reference Numbers are given below:

X-225 A

Node 50 PFSK – 2238 [7.4.86]

Node 81 PFSK - 2337 [7.4.88 & 7.4.89]

Node 80 PFSK - 2470 [7.4.90 & 7.4.91]

Node 83 PFSK – 2471 [7.4.92 & 7.4.93]

X-225 B

Node 98 PFSK - 1936 [7.4.82]

Node 95 PFSK - 2009 [7.4.83]

Node 96 PFSK – 2072 [7.4.84 & 7.4.85]

Node 65 PFSK – 2270 [7.4.87]

Supports X-225 B [7.4.81]

Support numbers PFSK 1936 (Node 98), 2009 (Node 95), 2072 (Node 96) and 2270 (Node 65) were selected for review due to the proximity from the Torus Penetration Nozzle at Node 10. These locations also have the largest load contribution from the Torus internal PS submerged structure loads. The submerged loads are tabulated in the TES X-225 B Calculation on Page 7 of 40.

TES TAP Support Load Summary also provides result from individual Load Conditions [7.4.94]. The load summary provides DW, TH, SSE, Torus Internal and External loads. It was originally used to screen existing supports. The Torus Internal Loads summarized match the Pool Swell Support Loads for RHR. The Torus External Loads are unlabeled. However, they are consistent with 0.0 ΔP PS accident condition loads. This provided a conservative screening criterion for TES to determine which supports required additional evaluation.

Because of the proximity of PFSK 1936, 2009 and 2072 the calculation packages tend to discuss the loading for all three supports. Supports 1936 and 2072 are lateral snubbers that share a trunnion that is reinforced and welded to the main RHR suction piping. Support 2009 is a vertical strut adjacent to the trunnion.

Reported/ Recalculated Loads for Snubbers PFSK-1936 and 2072

Table I-175 –Snubbers Loads PFSK-1936 & PFSK-2072 - X-225 A&B

PFSK	Node	Load Direction (Lbf)	SSE	1.7ΔP PS NO External	PS Internal	SRSS	Design
1936	98	Fx1 +	5863	1250	4890	8490	
		Fx1 -	5863	1300	4890	8526	10828
2072	96	Fx3 +	2785	1940	4050	6606	
		Fx3 -	2785	2250	4050	6888	10228
PFSK	Node	Load Direction (Lbf)	SSE	0.0 ΔP PS NO External x 1.11	PS Internal Adjusted	SRSS	
1936	98	Fx1 +	5863	1388	978	6322	
		Fx1 -	5863	1443	978	6343	7655
2072	96	Fx3 +	2785	2153	810	4067	
		Fx3 -	2785	2498	810	4324	6916

Table Notes:

1. The load directions reported are in the Global Coordinate System. Snubbers are in a Global coordinate system rotated by 30^0. Snubber Rated Load is Maximum 10,828 lbf and Minimum 10,228 lbf.

2. Design Loads for each snubber are calculated based on the 30^0 rotation using the bounding + or – loading.
3. PS External Load Adjustment Factor from Section 5.1 is 1.11.
4. PS Internal Load Adjustment Factor discussed above is 0.20.
5. Final load reduction factor: PFSK-1936 is 0.71 and PFSK-2072 is 0.68

Reported/ Recalculated Loads for Strut PFSK-2009

Rated Load Maximum 33992 Minimum -25578 lbf

Design Load Maximum 30495 Minimum -15807 lbf

Internal PS Load 16449 lbf (X-225B Page 7 of 40)

Adjusted Internal PS Load is (0.2 x 16449) 3290 lbf

The support calculation provides the following information with respect to the Trunnion evaluation. Note: the failure of the trunnion as initially evaluated resulted in redesign of this support as a strut using the trunnion for the two lateral snubbers PFSK-1938 and PFSK-2072. Therefore, the vertical trunnion load was eliminated.

The following table provides the evaluation of the Trunnion for PFSK-1936, 2072. The final load is also the combined PS NO load for PFSK-2009 which was later added to reduce the vertical trunnion load:

Table I-176 –Snubbers Trunnion Loads PFSK-1936 & PFSK-2072 - X-225 A&B

Load Condition/ Event Combination	Vertical Load (lbf)
DW	988
SSE	4401
SRV	1510
PS Internal	16449
EC 9A (DW+SSE+SRV)	6899
0.0ΔP PS + PS Internal	21069
1.7ΔP PS +PS Internal	18679
0.0ΔP PS	4620
1.7ΔP PS	2230

9B (DW+0.0ΔP PS+ PS Internal)	22057
9D (DW+SSE+SRV+1.7ΔP PS+PS Internal)	25578
9D Adjusted (DW+SRSS (SSE, SRV, 1.11 x 0.0ΔP PS+0.2 x PS Internal)	10606

Table Notes:

1. This table uses loads from PSFK-2009 failed Trunnion Evaluation. Trunnion load is the same as used by TES for the replacement Strut load.
2. Load reduction factor for this Trunnion support is 10606/25578 for 0.0 ΔP NO.

Adjusted stress of 10606 psi at the trunnion is acceptable and meets Service Level A Allowable Stress value of 1.0 S_H = 17,100 psi.

PFSK-1936 Reported/ Adjusted Interaction Ratio

Table I-177 – PFSK-1936 Support Interaction Ratios - X-225 A&B

Support Component	Interaction Ratio	Adjustment Factor	Adjusted IR
Member Stress	0.19	0.71	0.13
Anchors	0.71	0.71	0.50
Snubber	0.38	0.67	0.25
Trunnion	0.92	0.88	0.81

Table Notes:

1. Structural components are compared to Service Level A Allowable Stress Values.
2. The load reduction from Table I-175 Table Note 5 above is 0.71 x IR = Adjusted Ratio for the Support Elements (i.e., Members and Anchor).
3. Snubber Rated Load (BP HSSA-20) 20 kips. The applied load in the support package as listed in Table 1-175 is 10828 lbf. The recalculated snubber load is 7655 or a reduction factor of 0.71. IR = 7655/20,000 = 0.38. The referenced B-P Catalog NFR77 the faulted Service Level D allowable load is 30 kips. The adjusted factor = 20/30 = 0.67.
4. The trunnion evaluation associated with the modification to add the PSFK-2009 strut was also completed in this package. The trunnion loads are a result of snubbers

PSFK-1936 and PSFK-2072. The maximum reported stress was for the CO case and the interaction ratio is 32969/36000 = 0.92. The CO case has no load reduction associated with it. The trunnion was compared to 2.4 S_H = 36,000 psi. Reconciled value as discussed in Section 2.13 is 2.4 S_H = 2.4 x 17,100 = 41,040 psi. The adjustment factor is 36/41 = 0.88.

The maximum IR = 0.81. The support is acceptable for 0.0 ∆P NO.

PFSK-2072 Reported/ Adjusted Interaction Ratio

Table I-178 – PFSK-2072 Interaction Ratio X-225 A&B

Support Component	Interaction Ratio	Adjustment Factor	Adjusted IR
Anchors	0.85	0.68	0.58
Baseplate	0.56	0.68	0.39
Snubber	0.69	0.67	0.46
Trunnion	0.92	0.88	0.81
Weld	0.39	0.68	0.26

Table Notes:

1. Structural components are compared to Service Level A Allowable Stress Values.
2. The load reduction from Table I-175 Table Note 5 above is 0.68 x IR = Adjusted Ratio for the Support Elements (i.e., Weld, Baseplate, Anchors).
3. Snubber Rated Load (BP HSSA-10) 10 kips. The applied load in the support package as listed in Table 1-175 is 10228 lbf. The recalculated snubber load is 6916 or a reduction factor of 0.68. IR = 6916/10,000 = 0.69. The referenced B-P Catalog NFR77 the faulted Service Level D allowable load is 15 kips. The adjusted factor = 10/15 = 0.67.
4. Trunnion is shared by PFSK-1936 and PFSK-2072. See Table I-177 Table Note 4 for details.

Based on the PSFK-1936 calculation these two snubbers were evaluated together with the pipe trunnion to which they are both attached. Therefore, the trunnion stress results from PFSK-1936 and the interaction ratio IR=0.81 are repeated here.

Based on evaluation in the calculation package the bounding IR = 0.81 for the trunnion. This support is acceptable for 0.0 ∆P NO.

PFSK-2009 Reported/ Adjusted Interaction Ratio

The recalculated trunnion load given above was reduced by a factor of 0.41 (10606/25578) based on the preceding table. Therefore, use an IR=0.41. The normal load rating for the Strut 2100-38 is 38,000 lbf. The faulted value is 47,880 lbf or an increase of 1.36 in accordance with the B-P Catalog 77NFR. The adjusted IR = 10606/47880 = 0.22.

The support is acceptable for 0.0 ∆P NO.

Reported/ Recalculated Loads for PFSK-2270

The design loads for this support are provided in the first revision that is attached to the current revision by JAF for completeness. In addition, the analyzed PS internal load for this support was also provided in the TES X-225 B calculation as 15095 lbf on Page 7 of 40.

Table I-179 – PFSK-2270 Load Summary - X-225 A&B

Load Condition	Support Load (lbf)	Adjusted Support Load (lbf)
DW	-8684	-8684
TH	-5566	-5566
SSE	±8257	±8257
PS Internal	15094	3019
PS External	+2460/ -2730	2731/ -3030
Total PS Support Load	10715/ -33894	1377/-24486

Table Notes:

1. The Adjustment Factor for the internal PS load to account for the Updated ECCS Suction Strainer with bellows to reduce penetration load is 0.20 as discussed above.
2. The Adjustment Factor for 0.0 ∆P PS NO from 0.0 ∆P PS Accident is 1.11 as discussed in Section 5.1.
3. The load reduction for the maximum load magnitude =24486/33894 = 0.72

PFSK-2270 Reported/ Adjusted Interaction Ratio

Table I-180 – PFSK-2270 Interaction Ratio X-225 A&B

Support Component	Interaction Ratio	Adjusted IR
U-bolt	0.55	0.40
8 NPS Pipe Stanchion	0.48	0.35
Bottom Plate	0.72	0.52
Anchors	0.52	0.38
Baseplate	0.50	0.37
Bearing Plate	0.58	0.42
Weld	0.46	0.34

Table Notes:

1. IR is adjusted by 0.72 as developed in the load table for this support.

The bounding IR = 0.72 for the bottom plate at the analyzed total load. Accounting for the load reduction the bounding IR = 0.72 x 0.72 = 0.52.

The support is acceptable for Continued Service at 0.0 ΔP PS NO.

Supports X-225 A [7.4.80]

Support number PFSK – 2238 (Node 50), 2337 (Node 81), 2470 (Node 80) and 2471 (Node 83) were selected for review due to the proximity from the Torus Penetration Nozzle at Node 10. These locations also have the largest load contribution from the Torus internal PS submerged structure loads. The submerged loads are tabulated in the TES calculation on Page 7 of 40.

TES TAP Support Load Summary also provides individual Load Conditions [7.4.94]. The load summary provides DW, TH, SSE, Torus Internal and External loads. It was originally used to screen existing supports. The Torus Internal Loads summarized match the Pool Swell Support Loads for RHR. The Torus External Loads are unlabeled. However, they are consistent with 0.0 ΔP PS accident condition loads. This provided a conservative screening criterion for TES to determine which supports required additional evaluation.

Reported/ Recalculated Loads for Strut PFSK-2337

The Service Level A Snubber Rated Load for the HSSA-30 is 30,000 lbf. The Service Level D rated load is 45,000 lbs based on the snubber catalog 77NFR1 [7.5.13].

The reported design loads are:

DW+TH+SSE = 24082 lbf

Internal PS Load =1680

External PS Load = 1040 lbf.

The calculated Design Load is 24235 lbf.

The adjusted design load is SQRT (SSE, 0.2 x Internal PS Load, 1.11 x External PS Load)

Adjusted Design Load = 24,128 lbf

The adjusted support loads are less than the TES Rated Loads. The support is acceptable for Continued Service at 0.0 ΔP PS NO.

Reported/ Recalculated Loads for Strut PFSK-2238

Table I-181 – PFSK-2238 Load Summary - X-225 A&B

Load Condition	Support Load (lbf)	Adjusted Support Load (lbf)	Rated Load (lbf)
DW	-8494	-8494	
TH	-5144	-5144	
SSE	7673	7673	
PS Internal	16528	3306	
PS External	8480	9413	
P+	17665	6360	29181
P-	-39797	-28492	-44169

Table Notes:

1. Load conditions not specified in the TES Calculation package were taken from Support Load Summary 5321-Loads
2. Adjusted support loads were calculated:

a. PS internal contribution was reduced by the factor of 0.20 calculated above.

b. PS external contribution was increased by the load condition adjustment factor provided in Section 5.1 which is 1.11.

The adjusted support loads are less than the TES Rated Loads. The support is acceptable for Continued Service at 0.0 ΔP PS NO.

Reported/ Recalculated Loads for Strut PFSK-2470

The reported design load is DW+TH+SSE = 11055 lbf and the Internal PS Load =14095 with an External PS Load = 9380 lbf. The calculated Design Load is 26165 lbf.

The adjusted design load is SQRT (SSE, 0.2 x Internal PS Load, 1.11 x External PS Load

Adjusted Design Load = 17566 lbf

The adjusted support loads are less than the TES Rated Loads. The support is acceptable for Continued Service at 0.0 ΔP PS NO.

Reported/ Recalculated Loads for Strut PFSK-2471

Snubber Rated Load 20,000 lbf

Rated Load Maximum 11,420 lbf Minimum -11,310 lbf

Note that the Structural Frame Rated Load is Maximum 15,577 lbf / Minimum -15388 lbf.

The reported design load is SSE = 4,200 lbf (note: for a snubber this is only SSE) and the Internal PS Load =5890 with an External PS Load = 4240 lbf. The calculated Design Load is 10,966 lbf.

The adjusted design load is SQRT (SSE, 0.2 x Internal PS Load, 1.11 x External PS Load):

Adjusted Design Load = 7,320 lbf

The adjusted support loads are less than the TES Rated Loads. The support is acceptable for Continued Service at 0.0 ΔP PS NO.

PFSK-2337 Reported/ Adjusted Interaction Ratio

Table I-182 – PFSK-2337 Interaction Ratio X-225 A&B

Support Component	Interaction Ratio	Adjusted IR
Anchor (Maximum)	0.34	0.34
Snubber	0.81	0.54

Table Notes:

1. The recalculated load and the previously rated load are the same (24128/24235 = 1.0). The Adjusted IR = 1.0 x IR.
2. The snubber rated load for Service Level A was used. The faulted load is a factor of 1.5 higher. The Adjusted IR = 0.67 x IR.

The support is acceptable for Continued Service at 0.0 ΔP PS NO.

PFSK-2238 Reported/ Adjusted Interaction Ratio

Table I-183 – PFSK-2238 Interaction Ratio X-225 A&B

Support Component	Interaction Ratio	Adjusted IR
Member Stress	0.59	0.38
Anchor (Maximum)	0.75	0.48
Baseplate (Maximum)	0.42	0.27
Weld	0.38	0.25

Table Notes:

1. The rated load is 44169 lbf and the Adjusted load is 39797 lbf. Loads were taken from 5321-Load calculation [7.4.94].
2. The load reduction above is 0.65. Adjusted IR = 0.65 x IR
3. Additional margin is available as the components were evaluated using Service Level A Allowable Stress Values.

The support is acceptable for Continued Service at 0.0 ΔP PS NO.

PFSK-2470 Reported/ Adjusted Interaction Ratio

The load is reduced from 26165 to 17566. The previous rated load is +42472/-36916 [7.4.95]. IR = 0.48

The support is acceptable for Continued Service at 0.0 ΔP PS NO.

PFSK-2471 Reported/ Adjusted Interaction Ratio

The following support frame was analyzed for a snubber load of 15577 lbf. The final rated load for this support was 11420 lbf. The actual load for PS (Internal and External) and SSE were taken from the TES Support Load summary [7.4.94].

Table I-184 – PFSK-2471 Interaction Ratio Adjustment Information X-225 A&B

Load Condition	Analyzed Load lbf	Adjusted Load lbf
SSE	4200	4200
PS Internal	5890	1178
PS External	4240	4706
Total Load	10966	7230

Support Component	Interaction Ratio	Adjusted IR
Weld	0.96	0.34
Anchors	0.86	0.54
Member Stress	0.29	0.13
Snubber	0.55	0.24

Table Notes:

1. PS Internal Load Adjustment Factor = 0.20
2. PS External Load Adjustment Factor = 1.11
3. The snubber rated load for Service Level A was used. The snubber is rated as an HSSA-20 at 20 kips. The faulted load is a factor of 1.5 higher at 30 kips. Analyzed Interaction Ratio = 10966/20000 lbf. Adjusted Interaction Ratio = 7230/30000 lbf = 0.24
4. The Overall Reduction Factor for structural elements (Weld, Anchors, Members) accounting for the Frame Analysis and the Load Reduction is 7230/15577 = 0.46.

The support is acceptable for Continued Service at 0.0 ∆P PS NO.

Table I-185 - X-227A Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Internal Piping	25	0.0 ΔP NO PS	1.31
External Piping	25	0.0 ΔP NO PS	1.18
Suction Strainer Supports	25	0.0 ΔP NO PS	1.08
Piping Supports	25	0.0 ΔP NO PS	1.25
X-225A & B Penetration	25	0.0 ΔP NO PS	1.45
Branch Line	25	0.0 ΔP NO PS	1.60
Nozzle/ Valves		Not Reported	1.18

X-227A Core Spray Pump Suction Piping

Calculation A384.F02-10 summarized in Section 2.17 contain the latest results for the TAP, Supports, Penetration X-227A and associated ECCS Suction Strainer [7.4.45]. These results have been reviewed and adjusted for 0.0 ΔP NO.

X-227A PIPE STRSS REVIEW

The TAP Stress Results were provided in Section 13.1 of the A384.F02-10 calculation for both the internal and external piping. The calculation also contains the individual Load Condition stress results in Attachment D. The Attachment D Event Combinations can be recalculated using the Load Conditions provided for 0.0 ΔP NO. The Load Condition Adjustment Factor for Inertial PS (External) as discussed in Section 2.17 is 1.11. The Load Condition Adjustment Factor for PS Submerged Structures (Internal) is 1.0. In accordance with the Structural Acceptance Criteria the piping is analyzed to Service Level B [7.2.1] requirements. However, the Table 5-2 annotation allows pipe stresses for the PS Event Combinations to meet the Service Level D Allowable Stress Value of 2.4 S_H. Section 3.3 provides additional information on the bounding Event Combinations.

The ECCS Suction Strainer packages combine loads in accordance with the Mk I Program Structural Acceptance Criteria [7.2.1]. However, Load Case numbers as defined in A384.F02-10 Tables 3-3 and 3-4 are used in place of the EC numbers provided in Tables 5-1 and 5-2 of the Structural Acceptance Criteria. LC 2 corresponds to EC 16 and LC 4 corresponds to EC 25 for Pipe Stress. LCs S-10 and S-20 correspond to EC 16 and LCs S-9 and S-19 correspond to EC 25 for Pipe Supports.

Table I-186 - X-227A Maximum Stress for External Piping

X-227A	Node	Maximum Stress (psi)	B31.1 Allowable (psi)	Reconciled Allowable Stress (psi)	Ratio
A384.F02-10	50	24756	2.4 S_H = 36000	2.4 S_H = 41040	1.66
EC 25 Recalculated 0.0 ΔP NO	50	27413	2.4 S_H = 36000	2.4 S_H = 41040	1.50

Table Notes;

1. PS Total = 1.0 x 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
2. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ SRSS (PS Total, SSE, SRV)
3. See Section 2.13 for discussion on Reconciled Allowable Stress Values. The piping model in Attachment A lists the piping material at Node 50 as Carbon Steel with properties consistent with A106 Gr B.

Table I-187 - X-227A Maximum Stress for Internal Piping

X-227A	Node	Maximum Stress (psi)	B31.1 Allowable (psi)	Reconciled Allowable Stress (psi)	Ratio
A384.F02-10	520	29906	2.4 S_H = 36000	2.4 S_H = 41040	1.37
EC 25 Calculated 0.0 ΔP NO	520	30861	2.4 S_H = 36000	2.4 S_H = 41040	1.33

Table Notes;

1. PS Total = 1.0 x 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
2. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ SRSS (PS Total, SSE, SRV)
3. `Attachment A lists the piping material at Node 520 as Carbon Steel with properties consistent with A106 Gr B.

X-227A PIPE PENETRATION REVIEW

Maximum Nozzle and Penetration Loads to be used for the Stress Evaluation are provided in Section 13.7 of Calculation A384.F02-10 [7.4.45].

Based on the piping model provided in Attachment G the Torus Penetration is at Node 5. The Nozzle Load (i.e., piping equilibrium forces and moments) for all Load Conditions (on both sides of the piping penetration) are provided in Attachments C and D. In addition, the Penetration Loads are provided in the Support Load Summary at Node 5 in Attachment F.

The torus free shell stress results reported in A384.F02-10 were taken from the original TES analysis. EC 16 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results using EC15 for the maximum free shell stresses. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid. Review the previous EC 16 results and determine if the assumption that the EC 16 is bounding still applies.

Table I-188 - X-227A Maximum Penetration Loads

X-227A Node 5	F1 (lbf)	F2 (lbf)	F3 (lbf)	M1 (in-lbf)	M2 (in-lbf)	M3 (in-lbf)
Reported Peak Bounding Load	25536	109828	53205	1539572	18146	42266
Calculated Peak Load 0.0 ∆P PS NO	26109	92846	41130	1542007	16770	43294
Ratio	1.02	0.85	0.77	1.00	0.92	1.02

Table Notes:

1. The A384.F02-10 calculation used the bounding force or moment load in each direction. They are not necessarily from the same Event Combination.
2. PS Total =1.0 x 0.0 ∆P Internal + 1.11 x 0.0 ∆P PS External
3. Recalculated Penetration Forces and Moments for 0.0 ∆P NO EC 25 is P+DW+ TE + SRSS (PS Total, SSE, SRV)
4. The average ratio is 0.93 for the 6 directions of forces and moments. Therefore, the A384.F02-10 results are considered bounding.

Table I-189 - X-227A Maximum Nozzle Loads

X-227A Node 5	F1 (lbf)	F2 (lbf)	F3 (lbf)	M1 (in-lbf)	M2 (in-lbf)	M3 (in-lbf)
Reported Peak Bounding Load	29435	53026	31539	1256736	1302774	1872494
Calculated Peak Load 0.0 ΔP PS NO	31492	47631	31403	1286881	912462	174968
Ratio	1.07	0.90	1.00	1.02	0.70	0.93

Table Notes:

1. The A384.F02-10 calculation used the bounding force or moment load in each direction. They are not necessarily from the same Event Combination.
2. PS Total = 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
3. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ TE + SRSS (PS Total, SSE, SRV)
4. The average ratio is 0.94 for the 6 directions of forces and moments. Therefore, the A384.F02-10 results are considered bounding.

Based on the results of the 0.0 ΔP NO EC 25 compared to the Maximum Forces and Moments reported in Calculation A384.F02-10 it is concluded that the loads used for the penetration evaluation are bounding and the previous penetration evaluation is acceptable for reporting of stress ratios.

Table I-190 - Reported Penetration Stress Results X-227A

X-227A	Penetration Location	Stress (psi)	Reported Allowable (psi)	Reconciled (psi)	Allowable/ Actual
P_L	Torus Shell at Nozzle	19896	$1.5S_{MC}$ = 28,950	33,000	1.66
P_L	Torus Penetration at Reinforcing Pad	23126	$1.5S_{MC}$ = 28,950	33,000	1.43
P_M	Nozzle	17809	$1.0S_{MC}$ = 19,300	22,000	1.24

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.

X-227A FLANGE REVIEW

A385.F02-10 Sections 13.2 and 13.3 report that the External Flanges are at nodes 122 and 140 of the Piping Analysis and the Internal Flanges are at Nodes 520, 580 and 610.

External Flange Nodes 135 and 150 are near the Pump 14B-1A Nozzle at Node 152. The adjusted pipe forces and moments (0.0 ∆P NO) at Node 152 (Table I-191) are 86% on average of the analytical values from A385.F02-10. Based on the reported allowable moments in A384.F02-10 Table 13.3.1 for the External Flanges there is ample margin available (~70%) to demonstrate the acceptability of adjusted forces and moments.

The external flanges are acceptable for continued service at 0.0 ∆P PS NO.

Internal Flange Nodes 520, 580 and 610:

- 520 is near the Torus Penetration Nozzle
- 580 and 610 are adjacent to the Strainer Support at Node 600.

The adjusted maximum forces and moments (0.0 ∆P NO) at the Nozzle, Node 5 (Table I-189) are 94% on average of the analytical values from A385.F02-10.

The adjusted maximum forces (0.0 ∆P NO) at the Ring Girder Support, Node 600 (Table I-191) are 87% on average of the analytical values from A385.F02-10.

The internal flanges are acceptable for continued service at 0.0 ∆P PS NO.

X-227A STRAINER CORE REVIEW

The Strainer Core Review considers local forces and moments as well as accelerations on the strainer and core pipe.

The maximum internal pipe stress increased by less than 1000 psi (29906 to 30861 psi). This increase is approximately 2% of the Allowable Stress Value (41040 psi) and considered negligible.

It is clear upon review of A384.F02-10, Attachment N that the local accelerations are dominated by LC3, SRSS (SSE, CO). LC 3 is a factor of 2 larger than LC2 (0.0∆P PS Accident) or LC4, SRSS (1.7∆P PS, SSE, SRV). It is concluded that the Maximum reported Level D accelerations remain valid for 0.0∆P PS NO.

Based on the review of the Peak Local Loads and Accelerations the current values are acceptable for 0.0∆P PS NO. These values are also used in Calculation A384.F02-19 [7.4.67].

X-227A PUMP NOZZLE AND VALVE EVALUATION

Pump

A385.F02-10 Section 13.5 reports the Core Spray Pump 14P-1A at Node 152. The nozzle was modeled as a 14 x 26 reducer mating with 14" Sch 40 Std pipe. The nozzle forces and moments were used to calculate pipe stress at the small end (i.e., pipe side) of the reducer as is typical for a nozzle to determine acceptability. The piping analysis used a SIF = 1.9 on the pipe side of the reducer. The maximum forces and moments at Node 152 are reported in Table I-191 below. The resulting stress calculated based on the applied moment values using the properties discussed herein is calculated as 12729 psi < 1.2 S_H = 20,520 psi.

Therefore, it is concluded that the pump is qualified for 0.0∆P PS NO with an interaction ratio at the nozzle of 1.61 (Allowable/ Reconciled Actual = 20,520/ 12,729).

Valve

The Level D valve stresses reported in the same section of A384.F02-10 are also well below the reconciled allowable of 1.2S_H = 20520 psi. Pipe Stress for 0.0 ∆P NO, Penetration Loads and Pump Nozzle Loads have increased less than 10%. Valve stress increase of 10% is conservatively considered for all valves. The interaction ratio based on the 10% increase in maximum reported stress value of 11526 (Table 13-5.2) is therefore, Allowable/ Reconciled Actual = 20520 psi/ 12679 psi = 1.62.

Therefore, it is concluded that the valves are qualified for 0.0 ∆P PS NO with an interaction ratio of 1.62.

X-227A WELDED ATTACHMENT EVALUATION

The maximum reported welded attachment stress in A385.F02-10 Section 13.6 is a Node 115 (13483 psi). However, this support is a deadweight support unaffected by the PS loading. Node 90 is the maximum reported load affected by the PS loading. The average support load increase at Node 90 is less than 1.0. Therefore, it is concluded that the welded attachment stresses are acceptable as reported in Section 13.6.

X-227A SUPPORT AND NOZZLE LOADS

The results for individual load conditions and associated ECs are found in the A384.F02-10 Attachment F Support Load Summaries. Sections 13.8 and 13.9 report the Peak External and Internal Support Loads, respectively from the attachment. Since the PS load condition is the focus, only Service Level D loads increase when considering 0.0 ∆P NO. Deadweight only supports are not affected by the PS loading and therefore, results are not reported below.

The discussion in Section 2.17.3.1, Timing Consideration of Pool Swell Inertia and Fallback concluded that the Inertia and Fallback load need not be added provided the summation of Inertia and Vent Clearing Load also be considered. Therefore, the DE&S S10 and S19 Event Combinations reported in the table below as adjusted for 0.0 ∆P NO have been refined with respect to the Inertia, Fallback and Vent Clearing as discussed.

Table I-191 - X-227A NOZZLE AND SUPPORT LOAD SUMMARY

Node	Designation	EC	F1 (lbs)	F2 (lbs)	F3 (lbs)	M1 (in-lbs)	M2 (in-lbs)	M3 (in-lbs)	AVG
45	PFSK-2511	Peak Reported	19800						
		Maximum S10 or S19 NO 0.0ΔP	16268						
		Maximum/ Reported	0.82						0.82
90	PFSK-2418	Peak Reported	10094	5093					
		Maximum S10 or S19 NO 0.0ΔP	6579	4107					
		Maximum/ Reported	0.65	0.81					0.73
152	Pump Nozzle 14P-1A	Peak Reported	5785	4273	6744	301280	450890	363193	
		Maximum S10 or S19 NO 0.0ΔP	4690	4762	6861	266934	366276	182039	
		Maximum/ Reported	0.81	1.11	1.02	0.89	0.81	0.50	0.86
250	PFSK-2122	Peak Reported	1823						
		Maximum S10 or S19 NO 0.0ΔP	1589						
		Maximum/ Reported	0.87						0.87
280	PFSK-2508	Peak Reported		6303					

Node	Designation	EC	F1 (lbs)	F2 (lbs)	F3 (lbs)	M1 (in-lbs)	M2 (in-lbs)	M3 (in-lbs)	AVG
		Maximum S10 or S19 NO 0.0ΔP		6518					
		Maximum/ Reported		1.03					1.03
295	PFSK-2325	Peak Reported	971	1847	1727	87897	84554	44110	
		Maximum S10 or S19 NO 0.0ΔP	1055	2113	1696	99376	64419	47624	
		Maximum/ Reported	1.09	1.14	0.98	1.13	0.76	1.08	1.03
345	H14-28	Peak Reported		3044					
		Maximum S10 or S19 NO 0.0ΔP		3275					
		Maximum/ Reported		1.08					1.08
350	PFSK-2394	Peak Reported	368	2664					
		Maximum S10 or S19 NO 0.0ΔP	375	2736					
		Maximum/ Reported	1.02	1.03					1.02
370	A9/S-253	Peak Reported	681	586	1428	48344	9701	16282	
		Maximum S10 or S19 NO 0.0ΔP	667	642	1401	50521	9249	18356	
		Maximum/ Reported	0.98	1.10	0.98	1.05	0.95	1.13	1.03

Node	Designation	EC	F1 (lbs)	F2 (lbs)	F3 (lbs)	M1 (in-lbs)	M2 (in-lbs)	M3 (in-lbs)	AVG
600	X-227A-S1	Peak Reported	48727	54916	17198				
		Maximum S10 or S19 NO 0.0ΔP	45795	48765	13201				
		Maximum/ Reported	0.94	0.89	0.77				0.87

Table Notes:

1. Sustained = Maximum Absolute Value of DW+TE or DW
2. PS Total = (1.11 x 0.0 ΔP PS External (Inertia) + 0.0 ΔP PS Vent Clearing) or (Fallback)
3. S10 = DW + SRSS (PS Total, SSE, SRV)
4. S19 = Sustained + SRSS (PS Total, SSE, SRV)
5. While downward loads are calculated in this table. The support DE&S PSUP calculations use the corresponding dynamic portion as +/- and remove downward static deadweight and thermal loading contribution for the upward load. Therefore, a reduction in IR calculated for downward load will be equivalent for upward load since the dynamic portion of the load contribution controls.

Table I-192 - X-227A SUPPORTED ADJUSTED INTERACTION RATIO SUMMARY

Node	Designation	Component	Adjusted IR	Comment
45	PFSK-2511	Anchor Bolt	0.86 x 0.82 = 0.71	Reference [7.4.69] Section 9.0 page 10 of 20 provides the New Interaction Ratio. Attachment C PG C4 provides calculation details for upward load. It will have a corresponding decrease.
90	PFSK-2418	Anchor Bolt	0.996 x 0.73 = 0.73	Reference [7.4.70] Section 10, Page 37 of 37.
250	PFSK-2122	Anchor Bolt	0.55 x 0.82 = 0.45	Reference [7.4.71] Page 1 of 1 provides a rated load of 2889 lbs. The new load summarized for Node 250 is 1589 lbs for an IR = 0.55 (1589/2889). The limiting component IR = 0.82 on a flare bevel weld analyzed in R0 page 5 of 7.

Node	Designation	Component	Adjusted IR	Comment
280	PFSK-2508	Anchor Bolt	0.85 x 1.03 = 0.88	Reference [7.4.72] Section 9, Page 8 of 16 provides maximum IR = 0.85.
295	PFSK-2325	Anchor Bolt Number 12	0.95 x 1.33/1.5 x 1.03 = 0.87	Reference [7.4.73] Section 9.0 provides the tube to baseplate weld IR = 0.95. However, Service Level B Allowable stress value was calculated using a 1.33 factor. Per NF 3251.2-1 [7.5.2] Service Level C factor of 1.5 is appropriate for the PS load conditions. IR = 0.95 x 1.33/1.5 = 0.84
345	H14-28	Strut End Attachment	0.87 x 0.75 = 0.65	Reference [7.4.74] shows the revised design and a calculation for the strut end attachment. Vertical load used was 3759 lbf. Actual load is 3275 lbf. IR = 3275/3759 =0.87. Note: Rev. 1 contains the analytical evaluation for the Strut End. The IR = 0.75.
350	PFSK-2394	Tube to Baseplate Weld	0.22 x 1.02 = 0.22	Reference [7.4.75] provides a design load of 1709 lbf. The analyzed load is 368 lbf. IR = 368/1709 = 0.215. The load increase from Table I-191 is 1.02. Note: Rev. 3 contains the design load for this direction.
350	PFSK-2394	Tube to Baseplate Weld	0.97 x 0.67 = 0.65	Reference [7.4.75] provides a design load of 2809 lbf. Actual load is 2736 lbf. IR = 2736/2809 = 0.97. However, based on review of the support calculation, anchor bolts are not controlling, and all other components were evaluated to Normal Operation allowable stress values. PS is a Level D event. Adjust IR by 1.5 factor per ASME Section III NF 3251.2-1 [7.5.2]. IR = 1/1.5 = 0.67. Note: Rev. 0 of this calculation contains the analytical evaluation of components.

Node	Designation	Component	Adjusted IR	Comment
370	A9/S-253	9.0 Support Weld at Flange	0.14 x 1.03 = 0.15	Reference [7.4.76] provides interaction ratios for the anchor components. The maximum IR = 0.14 at the Flange to 12 in diameter pipe sleeve weld. Average load increase based on the above table is 1.03.
600	X-227A-S1	9.10 Local Pipe	N/A (Service Level D)	Reference [7.4.66] The maximum reported IR = 1.02 in Section 11.1 is the Local Pipe Bearing Stress. Per Appendix F 1331.3 [7.5.2] bearing stress need not be evaluated for Service Level D events.
600	X-227A-S1	9.9.1 Bar Plate Bending	0.96/1.125 x 0.87 = 0.74	Reference [7.4.66] The Section 11.1 Bar Plate IR = 0.96. However, the evaluation used Sy as the allowable stress. Per Appendix F 1334.4 [7.5.2] the allowable bending stress for a doubly symmetric compact section is fFb = 1.5 x .75 Sy = 1.125 Sy. (f = plastic shape factor = 1.5 for a rectangular cross section.) The adjusted IR = 0.96/ 1.125 = 0.85.
600	X-227A-S1	9.5.5 Stiffened Column Shear	0.97 x 0.4 x 0.87 = 0.34	Reference [7.4.66] Stiffened column IR was developed using the Normal shear allowable stress of 0.4 Sy. Service Level D allowable is limited to Sy per Section 9.5.2, page 30. Per Section 11.1 and adjusting for the appropriate Service Level D allowable IR = 0.4 x 0.97 = 0.39.
600	X-227A-S1	9.12.1.3 Column to Baseplate Weld	0.93 x 0.87 = 0.81	Reference [7.4.66] The weld analysis conservatively used E60XXX electrode and assumed the entire weld was analyzed as 1/16" undersized. This is very conservative as Attachment E clearly indicates that all welds are full size except near the gussets

Node	Designation	Component	Adjusted IR	Comment
				(i.e., likely due to interference. Per Section 11.1 the IR = 0.93.

Table Note:

1. Maximum = MAX (S10, S20)
2. The Adjusted IR = Maximum/PEAK x Reported IR
3. The Reported and Adjusted IR values are the inverse of the Interaction Ratio as Reported in this Report 13-0541-TR-002

It is concluded that the maximum interaction of the supports reviewed is Adjusted IR = 0.88. The supports are adequate for 0.0 ΔP NO.

X-227A BRANCH CONNECTIONS

Branch Connection Displacements

Branch displacements reported in A384.F02-10 Section 13.10 were reviewed and EC 4 was recombined using the PS Load Condition Adjustment Factor from Table 13, 0.0 ΔP PS: Internal + 1.11 x External in place of the 1.7 ΔP PS Internal + External. The individual displacements were provided in A384.F02-11 Appendix H.

Table I-193 - X-227A Branch Connection Displacement Tables

Node/ Displacement (in) LC4: TE+2 x SRSS (1.7ΔP PS I+E, SRV, SSE)	X	Y	Z
40	2.62	1.62	1.47
110	0.008	0.081	0.098
125-135	0.004	0.027	0.062
167	0.141	0.072	0.039

Node/ Displacement (in) LC4: TE+2 x SRSS (1.11 x 0.0 ΔP PS I+E, SRV, SSE)	X	Y	Z	SRSS (X, Y, Z)
40	2.799	1.782	1.516	3.649
110	0.043	0.112	0.097	0.154

125 - 135	0.017	0.042	0.063	0.078
167	0.119	0.094	0.108	0.186

Node/ Displacement (in) REPORTED PEAK LCs 1 - 5	X	Y	Z	SRSS (X, Y, Z)
40	2.669	1.704	1.48	3.495
110	0.085	0.105	0.098	0.167
125 - 135	0.038	0.039	0.063	0.083
167	0.237	0.087	0.151	0.294

Node/ Displacement (in) LC4 0.0ΔP/PEAK	SRSS (X, Y, Z)
40	1.044
110	0.923
125 - 135	0.933
167	0.633

Table Notes:

1. For definition of the Load Cases used in A384.F02-10 see Table 3-3.

The previous displacements at Node 40 were found acceptable in A384.F02-10 based on additional analysis completed by TES. The displacements were conservatively factored by 2.0 to address stress range. However, the PS loading is a one-time event and per the Structural Acceptance Criteria Table 5-2 Note 3 fatigue is not a consideration for the PS ECs. Therefore, a small increase of 11% is not a concern. The 0.0ΔP PS displacements at Nodes 110, 125 – 135 and 167 were not the bounding EC. It is concluded that the Branch Line displacements are acceptable.

Branch Connection Stress

The maximum reported Service Level D pipe stress from A384.F02-10 Section 13.10.2 is 15855 psi. This is well below the 2.4 S_H = 41040 psi allowable stress value. Maximum Pipe Stress reported for X-227A increased by 11% for 0.0ΔP NO [Table I-186: 27413/24756-1). Therefore, the stress ratio is 41040/ (1.11 x 15855) = 2.33

Table I-194 - X-227A Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP NO PS	1.33
Support	25	0.0 ΔP NO PS	1.14
X-227A Penetration	15, 16, 21 &25	Envelop	1.24
Branch Line	15, 16, 21 &25	Envelop	2.33
Nozzle/ Valves	25	0.0 ΔP NO PS	1.41

X-227B Core Spray Pump Suction Piping

Calculation A384.F02-11 summarized in Section 2.17 contain the latest results for the TAP, Supports, Penetration X-227A and associated ECCS Suction Strainer [7.4.46]. These results have been reviewed and adjusted for 0.0 ΔP NO.

X-227B PIPE STRSS REVIEW

The TAP Stress Results were provided in Section 13.1 of the A384.F02-11 calculation for both the internal and external piping. The calculation also contains the individual Load Condition stress results in Attachment D. The Attachment D Event Combinations can be recalculated using the Load Conditions provided for 0.0 ΔP NO. The Load Condition Adjustment Factor for Inertial PS (External) as discussed in Section 2.17 is 1.11. The Load Condition Adjustment Factor for PS Submerged Structures (Internal) is 1.0. In accordance with the Structural Acceptance Criteria the piping is analyzed to Service Level B [7.2.1] requirements. However, the Table 5-2 annotation allows pipe stresses for the PS Event Combinations to meet the Service Level D Allowable Stress Value of 2.4 S_H. Section 3.3 provides additional information on the bounding Event Combinations.

The ECCS Suction Strainer packages combine loads in accordance with the Mk I Program Structural Acceptance Criteria [7.2.1]. However, Load Case numbers as defined in A384.F02-11 Tables 3-3 and 3-4 are used in place of the EC numbers provided in Tables 5-1 and 5-2 of the Structural Acceptance Criteria. LC 2 corresponds to EC 16 and LC 4 corresponds to EC 25 for Pipe Stress. LCs S-10 and S-20 correspond to EC 16 and LCs S-9 and S-19 correspond to EC 25 for Pipe Supports.

Table I-195 - X-227B Maximum Stress for External Piping

X-227B	Node	Maximum Stress (psi)	B31.1 Allowable (psi)	Reconciled Allowable Stress (psi)	Ratio
A384.F02-11	55	25989	2.4 S_H = 36000	2.4 S_H = 41040	1.58

EC 25 Recalculated 0.0 ΔP NO	55	28333	2.4 S_H = 36000	2.4 S_H = 41040	1.45

Table Notes;

1. PS Total = 1.0 x 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
2. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ SRSS (PS Total, SSE, SRV)
3. See Section 2.13 for discussion on Reconciled Allowable Stress Values. The piping model in Attachment A lists the piping material at Node 55 as Carbon Steel with properties consistent with A106 Gr B.

Table I-196 - X-227B Maximum Stress for Internal Piping

X-227B	Node	Maximum Stress (psi)	B31.1 Allowable (psi)	Reconciled Allowable Stress (psi)	Ratio
A384.F02-11	520	30083	2.4 S_H = 36000	2.4 S_H = 41040	1.36
EC 25 Recalculated 0.0 ΔP NO	520	31037	2.4 S_H = 36000	2.4 S_H = 41040	1.32

Table Notes;

1. PS Total = 1.0 x 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
2. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ SRSS (PS Total, SSE, SRV)
3. `Attachment A lists the piping material at Node 520 as Carbon Steel with properties consistent with A106 Gr B.

X-227B PIPE PENETRATION REVIEW

Maximum Nozzle and Penetration Loads to be used for the Stress Evaluation are provided in Section 13.7 of Calculation A384.F02-11 [7.4.46].

Based on the piping model provided in Attachment G the Torus Penetration is at Node 5. The Nozzle Load (i.e., piping equilibrium forces and moments) for all Load Conditions (on both sides of the piping penetration) are provided in Attachments C and D. In addition, the Penetration Loads are provided in the Support Load Summary at Node 5 in Attachment F.

The torus free shell stress results reported in A384.F02-11 were taken from the original TES analysis. EC 16 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results using EC15 for the maximum free shell stresses. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid. Review the previous EC 16 results and determine if the assumption that the EC 16 is bounding still applies.

Table I-197 - X-227B Maximum Penetration Loads

X-227B Node 5	F1 (lbf)	F2 (lbf)	F3 (lbf)	M1 (in-lbf)	M2 (in-lbf)	M3 (in-lbf)
Reported Peak Bounding Load	25807	113044	55143	1569311	18731	44472
Calculated Peak Load 0.0 ∆P PS NO	26408	93058	40969	1567443	16662	45535
Ratio	1.02	0.82	0.74	1.00	0.89	1.02

Table Notes:

1. The A384.F02-11 calculation used the bounding force or moment load in each direction. They are not necessarily from the same Event Combination.
2. PS Total =1.0 x 0.0 ∆P Internal + 1.11 x 0.0 ∆P PS External
3. Recalculated Penetration Forces and Moments for 0.0 ∆P NO EC 25 is P+DW+ TE + SRSS (PS Total, SSE, SRV)
4. The average ratio is 0.92 for the 6 directions of forces and moments. Therefore, the A384.F02-11 results are considered bounding.

Table I-198 - X-227B Maximum Nozzle Loads

Node 5	F1 (lbf)	F2 (lbf)	F3 (lbf)	M1 (in-lbf)	M2 (in-lbf)	M3 (in-lbf)
Reported Peak Bounding Load	32070	54193	33487	1295324	1353634	1941020
Calculated Peak Load 0.0 ΔP PS NO	34728	48315	31879	1326443	932287	1785774
Ratio	1.08	0.89	0.95	1.02	0.69	0.92

Table Notes:

1. The A384.F02-11 calculation used the bounding force or moment load in each direction. They are not necessarily from the same Event Combination.
2. PS Total = 0.0 ΔP Internal + 1.11 x 0.0 ΔP PS External
3. Recalculated stress for 0.0 ΔP NO EC 25 is P+DW+ TE + SRSS (PS Total, SSE, SRV)
4. The average ratio is 0.93 for the 6 directions of forces and moments. Therefore, the A384.F02-11 results are considered bounding.

Based on the results of the 0.0 ΔP NO EC 25 compared to the Maximum Forces and Moments reported in Calculation A384.F02-10 it is concluded that the loads used for the penetration evaluation are bounding and the previous penetration evaluation is acceptable for reporting of stress ratios.

Table I-199 - Reported Penetration Stress Results X-227B

X-227B	Penetration Location	Stress (psi)	Reported Allowable (psi)	Reconciled (psi)	Allowable/ Actual
P_L	Torus Shell at Nozzle	20057	$1.5S_{MC}$ = 28,900	33,000	1.65
P_L	Torus Penetration at Reinforcing Pad	23368	$1.5S_{MC}$ = 28,900	33,000	1.41
P_M	Nozzle	18455	$1.0S_{MC}$ = 19,300	22,000	1.19

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.

X-227B FLANGE REVIEW

A385.F02-11 Sections 13.2 and 13.3 report that the External Flanges are at nodes 135 and 150 of the Piping Analysis and the Internal Flanges are at Nodes 520, 580 and 610.

External Flange Nodes 135 and 150 are near the Pump 14B-1B Nozzle at Node 157. The average increase in pipe forces and moments (0.0 ∆P NO) at Node 157 (Table I-201) are 89% on average of the analytical values from A385.F02-11. Based on the reported allowable moments in Table 13.3.1 for the External Flanges there is ample margin available (~52%) to demonstrate the acceptability of adjusted forces and moments.

The external flanges are acceptable for continued service at 0.0 ∆P PS NO.

Internal Flange Nodes 520, 580 and 610:

- 520 is near the Torus Penetration Nozzle
- 580 and 610 are adjacent to the Strainer Support at Node 600.

The adjusted maximum forces and moments (0.0 ∆P NO) at the Nozzle, Node 5 (Table I-198) are 94% on average of the analytical values from A385.F02-11.

The adjusted maximum forces (0.0 ∆P NO) at the Ring Girder Support, Node 600 (Table I-201) are 86% on average of the analytical values from A385.F02-11.

The internal flanges are acceptable for continued service at 0.0 ∆P PS NO.

X-227B STRAINER CORE REVIEW

The Strainer Core Review considers local forces and moments as well as accelerations on the strainer and core pipe.

The maximum internal pipe stress increased by less than 1000 psi (30083 to 31037 psi). This increase is approximately 2% of the Allowable Stress Value (41040 psi) and considered negligible.

It is clear upon review of A384.F02-11, Attachment N that the local accelerations are dominated by LC3, SRSS (SSE, CO). LC 3 is a factor of 2 larger than LC2 (0.0∆P PS Accident) or LC4, SRSS (1.7∆P PS, SSE, SRV). It is concluded that the Maximum reported Level D accelerations remain valid for 0.0∆P PS NO.

Based on the review of the Peak Local Loads and Accelerations the current values are acceptable for 0.0∆P PS NO. These values are also used in Calculation A384.F02-19 [7.4.67].

X-227B PUMP NOZZLE AND VALVE EVALUATION

Pump

A385.F02-11 Section 13.5 reports the Core Spray Pump 14P-1B at Node 157. The nozzle was modeled as a 14 x 26 reducer mating with 14" Sch 40 Std pipe. The nozzle forces and moments were used to calculate pipe stress at the small end (i.e., pipe side) of the reducer as is typical for the nozzle to determine acceptability. The piping analysis used and a SIF = 1.9 on the pipe side of the reducer. The maximum forces and moments at Node 157 are reported in Table I-201 below. The resulting stress calculated based on the applied moment values using the properties discussed herein is calculated as 18877 psi < 1.2 S_H = 20,520 psi.

Therefore, it is concluded that the pump is qualified for 0.0∆P PS NO with an interaction ratio at the nozzle of 1.09 (Allowable/ Reconciled Actual = 20,520/ 18877).

Valves

The Level D valve stresses reported in the same section of A384.F02-11 are also well below the reconciled allowable of 1.2S_H = 20520 psi. Pipe Stress for 0.0 ∆P NO, Penetration Loads and Pump Nozzle Loads have increased less than 10%. Valve stress increase of 10% is conservatively considered for all valves. The interaction ratio based on the maximum reported stress value of 11179 (Table 13-5.2) is therefore, Allowable/Actual = 20520 psi/ 12297 psi = 1.67.

Table I-200 – Intentionally Blank Table X-227B

X-227B WELDED ATTACHMENT EVALUATION

The maximum reported welded attachment stress in A385.F02-11 Section 13.6 is a Node 125 (15400 psi). However, this support is a deadweight support unaffected by the PS loading. Node 102 is the maximum reported load affected by the PS loading. The average support load increase at Node 102 is less than 1.0. Therefore, it is concluded that the welded attachment stresses are acceptable as reported in Section 13.6.

X-227B SUPPORT AND NOZZLE LOADS

The results for individual load conditions and associated ECs are found in the A384.F02-11 Attachment F Support Load Summaries. Sections 13.8 and 13.9 report the Peak External and Internal Support Loads, respectively from the attachment. Since the PS load condition is the focus, only Service Level D loads increase when considering 0.0 ∆P NO. Deadweight only supports are not affected by the PS loading and therefore, results are not reported below.

The discussion in Section 2.17.3.1, Timing Consideration of Pool Swell Inertia and Fallback concluded that the Inertia and Fallback load need not be added provided the summation of Inertia and Vent Clearing Load also be considered. Therefore, the DE&S S10 and S19 Event Combinations reported in the table below as adjusted for 0.0 ∆P NO have been refined with respect to the Inertia, Fallback and Vent Clearing as discussed.

Table I-201 - X-227B NOZZLE AND SUPPORT LOAD SUMMARY

Node	Designation	EC	F1 (lbs)	F2 (lbs)	F3 (lbs)	M1 (in-lbs)	M2 (in-lbs)	M3 (in-lbs)	AVG
50	PFSK-2512	Peak Reported		18164					
		Maximum S10 or S19 NO 0.0ΔP		14020					
		Maximum/ Reported		0.77					0.77
102	PFSK-2454	Peak Reported	14473	7967					
		Maximum S10 or S19 NO 0.0ΔP	11091	4932					
		Maximum/ Reported	0.77	0.62					0.69
157	Pump Nozzle 14P-1B	Peak Reported	7305	5318	7689	598824	606051	423563	
		Maximum S10 or S19 NO 0.0ΔP	7409	5569	8382	375647	572573	235892	
		Maximum/ Reported	1.01	1.05	1.09	0.63	0.94	0.56	0.89
250	PFSK-2324	Peak Reported	1404						
		Maximum S10 or S19 NO 0.0ΔP	1120						
		Maximum/ Reported	0.80						0.80
275	PFSK-2323	Peak Reported		3700					

Node	Designation	EC	F1 (lbs)	F2 (lbs)	F3 (lbs)	M1 (in-lbs)	M2 (in-lbs)	M3 (in-lbs)	AVG
		Maximum S10 or S19 NO 0.0ΔP		3586					
		Maximum/ Reported		0.97					0.97
300	PFSK-1994	Peak Reported	968	2660	2040	135153	64270	52014	
		Maximum S10 or S19 NO 0.0ΔP	1071	2860	1993	157127	69153	62543	
		Maximum/ Reported	1.11	1.08	0.98	1.16	1.08	1.20	1.10
600	X-227B-S1	Peak Reported	47868	55428	17681				
		Maximum S10 or S19 NO 0.0ΔP	45636	48873	13134				
		Maximum/ Reported	0.95	0.88	0.74				0.86

Table Notes:

1. Sustained = Maximum Absolute Value of DW+TE or DW
2. PS Total = (1.11 x 0.0 ΔP PS External (Inertia) + 0.0 ΔP PS Vent Clearing) or (Fallback)
3. S10 = DW + SRSS (PS Total, SSE, SRV)
4. S19 = Sustained + SRSS (PS Total, SSE, SRV)

Table I-202 - X-227B Support Summary Adjusted Interaction Ratio Summary

Node	Designation	Component	Adjusted IR	Comment
50	PFSK-2512	Anchor Bolt	0.86 x 0.77 = 0.66	Reference [7.4.69] Attachment 1 Provides New Interaction Ratio. Attachment C Page C4 provides calculation details for upward load. It will have a corresponding decrease.

Node	Designation	Component	Adjusted IR	Comment
102	PFSK-2454	Anchor Bolt	0.996 x 0.69 = 0.69	Reference [7.4.70] Section 10, Page 37 of 37.
250	PFSK-2324	Upper Base Plate Bolts.	0.81 x 0.80 = 0.65	Reference [7.4.77] provides a load rating of 2529 lbf for this support. Maximum reported IR = 0.81 for Upper Base Plate Bolts.
275	PFSK-2323	Anchor Bolt	0.79 x 0.97 = 0.77	Reference [7.4.78] Section 9.0 provides an interaction summary.
300	PFSK-1994	Local Pipe Stress at Stanchion	0.83 x 1.10 = 0.91	Reference [7.4.79] Section 10 summarizes the controlling IR = 0.92. It is a peak stress at the pipe to stanchion intersection. Per the Structural Acceptance Criteria [7.2.1] Note 5 to Table 5-2 Fatigue requirements are not applicable to PS Event Combinations. The next IR = 0.83 for the Anchor Bolts.
600	X-227B-S1	9.10 Local Pipe	N/A (Service Level D)	Reference [7.4.66] The maximum reported IR = 1.02 in Section 11.1 is the Local Pipe Bearing Stress. Per Appendix F 1331.3 [7.5.2] bearing stress need not be evaluated for Service Level D events.
600	X-227B-S1	9.9.1 Bar Plate Bending	0.96/1.125 x 0.86 = 0.73	Reference [7.4.66] The Section 11.1 Bar Plate IR = 0.96. However, the evaluation used Sy as the allowable stress. Per Appendix F 1334.4 [7.5.2] the allowable bending stress for a doubly symmetric compact section is fFb = 1.5 x .75 Sy = 1.125 Sy. (f = plastic shape factor = 1.5 for a rectangular cross section.) The adjusted IR = 0.96/ 1.125 = 0.85.

Node	Designation	Component	Adjusted IR	Comment
600	X-227B-S1	9.5.5 Stiffened Column Shear	0.97 x 0.4 x 0.86 = 0.33	Reference [7.4.66] Stiffened column IR was developed using the Normal shear allowable stress of 0.4 Sy. Service Level D allowable is limited to Sy per Section 9.5.2, page 30. Per Section 11.1 and adjusting for the appropriate Service Level D allowable IR = 0.4 x 0.97 = 0.39.
		9.12.1.3 Column to Baseplate Weld	0.93 x 0.86 = 0.80	Reference [7.4.66] The weld analysis conservatively used E60XXX electrode and assumed the entire weld was analyzed as 1/16" undersized. This is very conservative as Attachment E clearly indicates that all welds are full size except near the gussets (i.e., likely due to interference). Per Section 11.1 the IR = 0.93.

Table Note:

1. Maximum = MAX (S10, S20)
2. The Adjusted IR = Maximum/PEAK x Reported IR
3. The Reported and Adjusted IR values are the inverse of the Interaction Ratio as Reported in this Report 13-0541-TR-002

It is concluded that the maximum interaction of the supports reviewed is Adjusted IR = 0.91. The supports are adequate for 0.0 ΔP NO.

X-227B BRANCH CONNECTIONS

Branch Connection Displacements

Branch displacements reported in A384.F02-11 Section 13.10 were reviewed and EC 4 was recombined using the PS Load Condition Adjustment Factor from Table 13, 0.0 ΔP PS: Internal + 1.11 x External in place of the 1.7 ΔP PS Internal + External. The individual displacements were provided in A384.F02-11 Appendix H.

Table I-203 - X-227B Branch Connection Displacement Tables

Node/ Displacement (in) LC4: TE+2 x SRSS (1.7ΔP PS I+E, SRV, SSE)	X	Y	Z

40	2.645	1.743	1.481
122	0.013	0.115	0.097
140-145	0.006	0.042	0.062
172	0.114	0.096	0.030

Node/ Displacement (in) LC4: TE+2 x SRSS (1.11 x 0.0 ΔP PS I+E, SRV, SSE)	X	Y	Z	SRSS (X, Y, Z)
40	2.412	2.038	1.596	3.538
122	0.075	0.151	0.097	0.194
140-145	0.038	0.061	0.061	0.094
172	0.215	0.125	0.114	0.274

Node/ Displacement (in) REPORTED PEAK LCs 1 - 5	X	Y	Z	SRSS (X, Y, Z)
40	2.687	1.856	1.502	3.595
122	0.092	0.127	0.098	0.185
140-145	0.043	0.05	0.062	0.091
172	0.193	0.108	0.175	0.282

Node/ Displacement (in) LC4 0.0ΔP NO/PEAK	SRSS (X, Y, Z)
40	0.984

122	1.051
140-145	1.039
172	0.971

Table Note:

1. For definition of the Load Cases used in A384.F02-10 see Table 3-3.

The previous displacements at Node 40 were found acceptable in A384.F02-11 based on additional analysis completed by TES. The displacements were conservatively factored by 2.0 to address stress range. However, the PS loading is a one-time event and per the Structural Acceptance Criteria Table 5-2 Note 3 fatigue is not a consideration for the PS ECs. Therefore, a small increase of 11% is not a concern. The 0.0ΔP PS displacements at Nodes 122, 140 – 145 and 172 were not the bounding EC. It is concluded that the Branch Line displacements are acceptable.

Branch Connection Stress

The maximum reported Service Level D pipe stress from A384.F02-11 Section 13.10.2 is 17376 psi. This is well below the 2.4 S_H = 41040 psi allowable stress value. Maximum External Pipe Stress reported for X-227B increased by 9% for 0.0ΔP NO [Table I-195: 28333/25909-1]. Therefore, the stress ratio is 41040/ (1.09 x 17376) = 2.17.

Table I-204 - X-227B Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP NO PS	1.32
Support	25	0.0 ΔP NO PS	1.10
X-227A Penetration	15, 16, 21 &25	Envelop	1.19
Branch Line	15, 16, 21 &25	Envelop	2.17
Nozzle/ Valves	25	0.0 ΔP NO PS	1.09

X-210A & X-211A RHR Discharge Piping

The calculations reviewed are Penetration X-210A/211A R2, "Torus Attached Piping Analysis," September 1983 [7.4.52].

X-210A/211A PIPE STRESS REVIEW

The TES reported pipe stress results given below were in part based on Test Model Results as discussed below. These results are conservative but inconsistent with the other Large Bore packages.

Table I-205 - Reported Pipe Stress Results from X-210A/211A

TES TAP	Event Combination	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	7,025	1.0 S_H = 15,000
1a		P+DW+OBE	14,129	1.2 S_H = 18,000
1b		P+DW+SRV	11,719	1.2 S_H = 18,000
1c	3	P+N+EQ+SRV	20,904	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	29,708	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	20,904	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	31,961	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	20,905	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.52 Page 2 of 2

Adjusted Pipe Stress Results from X-210A/211A

Based on the results from the stress calculation, the maximum internal PS load was calculated at Node 355, with the maximum SIF at Node 50 [7.4.52 Page 4-5 of 22]. A review of Test Model pipe stress comparison showed that the DBACO RMS moments were controlling among all the torus dynamics for most nodes [7.4.52 Page 7-10 of 40]. There the DBACO stress (4694 psi) was substituted for the SRV, PS1, PS2 or Post-CHUG stresses during the piping evaluation. This was validated based on the notes on the branch line stress calculations [7.4.52 Page 27-31 of 40]. LC4 is then recalculated based on the 0.0 ΔP NO condition as in Table I-206 by SRSS of the dynamic loads plus the static loads.

Table I-206 - LC4 for 0.0 ΔP NO (1) - X-210A/211A

Label	Load	Stress psi	Reference
A	DW+SLP	7025	[7.4.52 Page 1 of 1]
B	EQ	16210-7025=9185	[7.4.52 Page 26 of 40]
C	SRV	4694	[7.4.52 Page 26 of 40]
D	PS1 Internal	17989	[7.4.52 Page 26 of 40]
E	PS1 External	4694	[7.4.52 Page 26 of 40]
F	LC4 0.0 ΔP Accident	31943	$=A+(B^2+C^2+(D+E)^2)^{1/2}$
G	LC4 0.0 ΔP NO	32414	$=A+(B^2+C^2+(D*1.00+E*1.11)^2)^{1/2}$
H	Reconciled B31.1 Allowable Stress Value psi	41040	Section 2.13 Table 11. 2.4 S_H = 2.4*17,100 psi
I	Allowable/LC4	1.27	I/H

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination.
2. The PS Load Condition is the Combination of PS loads from the piping external to the torus and internal to the torus.
3. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ΔP Accident Conditions [7.4.52 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping.
4. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↑ Upload Phase Accident Condition to obtain 0.0 ΔP PS ↑ Upload NO for the Torus Internal Structure is 1.0 based on the controlling Froth Load Condition discussed in Note 3 above [Section 5.1 Table 13].
5. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase Accident Condition to obtain 0.0 ΔP PS ↓ Download NO for the Torus External Piping Load Condition is 1.11 [Section 5.1 Table 13].
6. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate the 0.0 ΔP PS NO Torus External Pipe stress with the Torus Internal Pipe stress the total EC 25 stress is 32,414 psi and is the controlling EC. The updated TES evaluation demonstrates that the piping design is adequate for continued service at 0.0 ΔP NO.

X-210A/211A PIPE SUPPORT REVIEW

Pipe Support Loads and Displacements for the PS case were reported in the X-210A/X-211A calculation. [7.4.52 Pages 6 & 7 of 83]. The TES reported support loads compare well with the TES support loads from the X-210B/ X-211B package. A more detailed review of the X-210B/X-211B package was performed and it was determined that the load increase for 0.0 ΔP NO is less than 10% for the PS EC.

This increase can easily be accommodated by the existing support designs. JAF supports were designed to Service Level A Allowable Stress Values. The 0.0 ΔP PS case is listed in Table 5-2 of the PUAAG as

Level B [7.2.1]. A commensurate increase in support load would be easily accommodated by the 1.33 increase in the Service Level B Allowable Stress Value for EC 25.

X-210A/211A PIPE PENETRATION REVIEW

The torus shell penetration X-210A and X-211A were evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

X-210A

EC 16 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results using EC15 for the maximum free shell stresses. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid. Review the previous EC 16 results and determine if the assumption that the EC 16 is bounding still applies (Table I-207 to Table I-210).

Table I-207 - Reported Penetration Stress Results X-210A

X-210A	Penetration Location	Stress psi	Reported Allowable psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	17173	$1.5S_{MC}$ = 28,900	33,000	1.96
P_L	Torus Penetration at Reinforcing Pad	27572	$1.5S_{MC}$ = 28,900	33,000	1.20
P_M	Nozzle	12610	$1.0S_{MC}$ = 19,300	22,000	1.74

Table Notes:

2. Reconciled allowable stress is from Section 2.13 Table 11.
3. Reported stresses were from 7.4.52 Page 28 and 31 of 83.

Table I-208 - Reported Individual Penetration Loads X-210A

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	2153	-2839	198	18228	-1884	-6684
TH	680	-732	-154	34956	3120	-13740
EQ	7877	1936	1776	130356	14640	34836
SRV	970	6810	6410	41350	560	470
CO	7694	8543	7064	116850	4510	24336
PS1 (0.0 ΔP) Accident	12436	9617	1664	40858	2487	23158
PS1 (0.0 ΔP) Accident - Submerged	26280	11566	13743	271220	1000	4000

Table Notes:

1. Reported loads were from 7.4.52 Pages 14 - 18 of 83.
2. SRV Loads were taken from the Test Model Output on 7.4.52 Page 17 of 83.

Table I-209 - PS Load Adjusted for 0.0 ∆P Normal Operation X-210A

Load Condition	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
0.0 ∆P PS Accident	12436	9617	1664	40858	2487	23158
0.0 ∆P PS NO	13804	10675	1847	45352	2761	25705
Submerged 0.0 ∆P PS Accident	26280	11566	13743	271220	1000	4000
Submerged 0.0 ∆P PS NO	26280	11566	13743	271220	1000	4000

Table Notes:

1. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ∆P Accident Conditions 7.4.52 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
2. The Load Condition Adjustment Factor for the 0.0 ∆P PS ↑ Upload Phase Accident Condition to obtain 0.0 ∆P PS ↑ Upload NO for the Torus Internal Structure is 1.0 based on the controlling Froth Load Condition discussed in Note 3 above [Section 5.1 Table 13].
3. The Load Condition Adjustment Factor for the 0.0 ∆P PS ↓ Download Phase Accident Condition to obtain 0.0 ∆P PS ↓ Download NO for the Torus External Piping Load Condition is 1.11 [Section 5.1 Table 13].

Table I-210 - Adjusted Event Combinations – Forces and Moments X-210A

EC	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
16 Reported	N+TH+0.0 ∆P PS Accident	41549	24754	15451	365262	4723	47582
21 Reported	N+TH+SSE+ CO	13844	12331	7328	228246	16555	62919
16 Adjusted	N+TH+0.0 ∆P PS NO	42917	25812	15634	369756	4997	50129
25 Adjusted	N+TH+SSE+ SRV+0.0 ∆P PS NO	43695	26912	16994	398033	16362	66208
SRSS - EC 16 Reported		50772			368378		
SRSS - EC25 0.0 ∆P PS NO Adjusted		54058			403833		
SRSS - EC25 0.0 ∆P PS NO/ SRSS - EC 16 Reported		1.06			1.10		

Table Notes:

1. The 0.0 ∆P PS Accident Condition Load Condition Adjustment Factor for External Piping NO is 1.11 [Section 5.1 Table 13]
2. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ∆P Accident Conditions [7.4.52 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
3. 0.0 ∆P Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.00 [Section 5.1 Table 13]
4. The PS Internal and External load conditions are combined by summation. Where: E is External to the Torus and I is Internal to the torus:

   $$\text{EC 25} := |\mathrm{DW} + \mathrm{TH}| + \sqrt{(\mathrm{PSI} + \mathrm{PSE})^2 + \mathrm{SRV}^2 + \mathrm{SSE}^2}$$

5. The SRSS of the three forces and the SRSS of the three moments and comparison of the ratio of the Adjusted EC25 0.0 ∆P PS NO and the reported EC 16 0.0 ∆P PS Accident Condition will be used to update the External Stress evaluation for the X-210A Torus Penetration. The maximum ratio is 1.10.

Based on a review of the Table I-210- Reported/ Adjusted EC – Forces and Moments EC 25 is the bounding 0.0 ∆P NO. Therefore, the local membrane stress for the penetration and nozzle will be reevaluated for 0.0 ∆P PS NO.

Table I-211 - Local Membrane Stress at Penetration X-210A

Torus Shell at Nozzle intersection stress psi	External Stress		Free Shell Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	4683	5151	12200	12200	16883	17351
σ_x	4612	5073	2729	2729	7341	7802
$\tau_{x\theta}$	1515	1667	174	174	1689	1841
			Max Principal Stress		17173	17694
Torus Shell at Edge of Reinforcement Stress psi	External Stress		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	17952	19747	9186	9186	27138	28933
σ_x	12358	13594	6948	6948	19306	20542
$\tau_{x\theta}$	1512	1663	383	383	1895	2046
			Max Principal Stress		27572	29406
Nozzle stress, psi	External Stress		Discontinuity Stress		Sum	
	Original	Update	Original	Update	Original	Update
σ_θ	0	0	12200	12200	12200	13420
σ_x	1169	1337	2729	2729	3898	4339
$\tau_{x\theta}$	1717	1871	174	174	1891	2063
			Max Principal Stress		12610	13867

Table Notes:

1. References 7.4.52 Page 27 & 31 of 83.
2. Based on a review of the maximum torus free shell stress ECs in Attachment A, the PS EC free shell stresses are bounded by those reported for the DBACO ECs. The free shell stress results selected remain valid and are therefore updated by a factor of 1.0.
3. Stress from external load was Updated (multiplied by 1.10) based on the results from Table I-210
4. External Nozzle Stress was recalculated using the adjusted EC 25 results from Table I-210 based on the original calculation in the X-210A/211A package [7.4.52 Page 20 of 83].
5. Principal stress results are calculated per DISTRES [Section 2.9]:

$$\frac{Sx+Sy}{2} \pm \sqrt{\left(\frac{Sx-Sy}{2}\right)^2 + \tau xy^2}$$

6. Thus, the penetration stress is updated as in Table I-212. This penetration is adequate.

Table I-212 - Updated Penetration Stress Results X-210A

X-210A	Penetration Location	Stress psi	Reported Allowable psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	17694	$1.5S_{MC}$ = 28,900	33,000	1.87
P_L	Torus Penetration at Reinforcing Pad	29406	$1.5S_{MC}$ = 28,900	33,000	1.12
P_M	Nozzle	13867	$1.0S_{MC}$ = 19,300	22,000	1.57

X-211A

The evaluation of the X-211A and X-211B Torus Penetrations was reviewed with X-210B and X-211B. The original TES calculation performed the review for both X-211A and X-211B [7.4.36 Page 74 of 83]. Based on our review the penetration reported penetration stress results are valid for 0.0 ∆P NO.

Table I-213 - Reported Penetration Stress Results X-211A

X-211AB	Penetration Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	12556	$1.5S_{MC}$ = 28,900	33,000	2.63
P_L	Torus Shell at Reinforcing Pad	13672	$1.5S_{MC}$ = 28,900	33,000	2.41
P_M	Nozzle	12436	$1.0S_{MC}$ = 15,100	17,300	1.39

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from either 7.4.36 or 7.4.52 Page 80 and 83 of 83.

X-210A/211A BRANCH LINE REVIEW

The branch line stress calculated shows that the LC4 was the controlling case for all the branch lines in X-210A/211A [7.4.52 Page 10-18 of 22]. The stresses are adjusted for the 0.0 ∆P NO loading condition, shown in Table I-214.

Table I-214 - Adjusted Branch Line Stress Calculation X-210A/211A

Stress psi	DW	SLP	SSE EQ	SRV	P1 EXT	PS1 INT	LC4	Reconciled Allowable	Allowable/ Actual
4" W25-152-41A (6)	1281	1488	4371	2003	2003	6939	13425	41040	3.06
3"W20-152-16(6)	5526	1488	12051	1884	1884	5309	21420	41040	1.92
2"W22-152-15(6)	5526	1488	12051	2110	2110	5754	21845	41040	1.88
4"W20-152-40A (6)	1974	1488	13675	1889	1889	6065	19656	41040	2.09
3"W23-152-7A (6)	1796	993	5300	1533	1533	6950	13345	41040	3.08
1.5"W23-302-10A (7)	403	1164	1742	0	0	0	3309	41040	12.40
1"W23-302-29A (7)	427	1164	6480	0	0	0	8071	41040	5.08
3"-W23-302-6A (7)	449	1164	6888	0	0	0	8501	41040	4.83
4"-WLP-302-123(7)	569	1422	962	0	0	0	2953	41040	13.90
2"-AS-302-55A	2329	1324	4231	0	0	0	7884	41040	5.21

Table Notes:

1. References: 7.4.52 Page 27-36 of 40, Section 5.1 Table 13.
2. 0.0 ∆P PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11.
3. The torus internal structure load conditions are Froth, Fallback, Submerged Structure LOCA Jet and Bubble and Impact and Drag loads. LOCA Jet and Bubble were calculated at 0.0 ∆P Accident Conditions [7.4.52 Page 32 - 34 of 83]. TES concluded that the Froth loads control the remaining torus internal structure load conditions by a factor of 1.58 (34174/ 21674). Note: Impact loads are also applied but TES noted it does not to have a significant effect on the piping or penetration. Node 7 is a Support Internal to the Torus and based on the TES results it is the Support affected by the Impact and Drag Loading.
4. 0.0 ∆P Accident Condition Loading Submerged Loading for Internal Piping – Adjustment Factor for Normal Operation is 1.00 [Section 5.1 Table 13].
5. Internal Submerged Loads are combined and added absolutely to External Loading.

$$\text{EC 25:} = |P + DW| + \sqrt{(PSI + PSE)^2 + SRV^2 + SSE^2}$$

6. The Allowable Stress Value, S_H is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi. $2.4S_H$=41,040 psi.
7. No. SRV, PS1, PS2 or Post-Chug (external) analyses were completed by TES, DBACO stress is substituted for these branch line load conditions (DBACO was determined by TES to envelope all Torus Load Conditions).

The Branch line piping is adequate for continued service at 0.0 ΔP NO

X-210A/211A VALVE REVIEW

The stresses for partial valves/pump in the penetrations are shown in below table.

Table I-215 - Stresses in Valves/Pump X-210A/211A

Valve/Pump Designation	Maximum Stress psi	1.2 S_H psi	Allowable/Maximum Stress
MOV-34A	4425	20520	4.64
MOV-39A	2982	20520	6.88
MOV-26A	5801	20520	3.54
MOV-38A	5379	20520	3.81

Table Notes:

1. Reference: 7.4.52 Page 1 of 10.
2. All maximum stress values are from LC 3 (DBA CO).

Adequate stress margin exists to demonstrate that all valves will perform their design function even using the estimated EC 25 0.0 ΔP PS Normal Operation pipe stress and limiting the B31.1 Allowable Stress Value to Service Level B. Based on a review of 0.0 ΔP PS Accident Condition loads provided for LC 2 (EC 16) at Pump 14P-1A the change in loads resulting from 0.0 ΔP PS NO will be less than 10% and considered negligible.

Table I-216 - X-210A/X-211A Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	25	0.0 ΔP PS NO	1.27
Support	-	-	
X-210A Penetration	25	0.0 ΔP PS NO	1.12
X-211A Penetration	21	DBA CO	1.39
Branch Line	25	0.0 ΔP PS NO	1.88
Valves	21	DBA CO	3.54

X-213A/B Drain Piping

The calculations reviewed are Penetration X-213A/B R1, "FitzPatrick NPP Torus Attached Piping Analysis X-213A/B," August 1983 [7.4.53]

X-213A/B PIPE STRESS REVIEW

Table I-217 - Reported Pipe Stress Results X-213A/B

TES TAP	EC	Load Conditions	Pipe Stress psi	B31.1 Allowable Stress Value psi
B31.1	Equation 8	Sustained	1,418	1.0 S_H = 15,000
1	3	P+N+EQ+SRV	15,465	1.8 S_H = 27,000
2	16	P+N+0.0 ΔP PS	10,628	2.4 S_H = 36,000
3	21	P+N+EQ+DBA CO	31,195	2.4 S_H = 36,000
4	25	P+N+EQ+SRV+1.7 ΔP PS	16,553	2.4 S_H = 36,000
5	27	P+N+EQ+SRV+Post CH	18,271	2.4 S_H = 36,000

Table Notes:

1. EQ indicates controlling EQ load of the two cases (i.e., OBE or SSE).
2. Reference: 7.4.53 Page 2 of 2

Adjusted Pipe Stress Results from X-213A/B

Based on the results the individual stress contribution for each load condition is calculated in Table I-218.

Table I-218 - Individual Load Condition Contributions per EC X-213A/B

TES TAP	EC	Load Conditions psi	Pipe Stress psi	B31.1 Allowable Stress Value psi	Reconciled Value psi	Allowable/ Actual
B31.1	Equation 8	Sustained P+N	1,418	1.0 SH = 15,000	17,100	12.06
1	3	P+N+EQ+SRV P+N = 1418 EQ+SRV = 14047	15,465	1.8 SH = 27,000	30,780	1.99
2	16	P+N = 1418 0.0 ΔP PS = 9210	10,628	2.4 SH = 36,000	41,040	3.86
3	21	P+N+EQ +DBA CO	31,195	2.4 SH = 36,000	41,040	1.32
4	25 - 1.7 ΔP NO	P+N+EQ+SRV = 15465 1.7 ΔP PS = 1088	16,553	2.4 SH = 36,000	41,040	2.48
4	25 – 0.0 ΔP (Accident)	P+N+EQ+SRV = 15465 0.0 ΔP PS = 9210	24,675	2.4 SH = 36,000	41,040	1.66
4	25 – 0.0 ΔP (NO)	P+N+EQ+SRV = 15465 0.0 ΔP PS = 9210 x 1.11	25,688	2.4 SH = 36,000	41,040	1.60
5	27	P+N+EQ+SRV+Post CH	18,271	2.4 S_H = 36,000	41,040	2.25

Table Notes:

1. The location of maximum stress in the piping system may vary for each Event Combination
2. Adjustment for Accident Condition 0.0 ΔP PS ↓ Download Phase NO is 1.11 [Section 5.1 Table 13]. This largest adjustment factor was conservatively used for EC 25 adjustment.
3. S_H Value is increased per Section 2.13 Table 11 from 15,000 to 17,100 psi.

Based on the adjustment to EC 25 to incorporate 0.0 ΔP PS NO, the Torus External Piping stress for both EC 16 and 25 is less than EC 21 (31,195 psi) which remains the controlling EC.

X-213A/B PIPE SUPPORT REVIEW

No pipe support loads were reviewed in 7.4.53. New TES Pipe support 8332 and 8333 load summaries for X-213A and X-213B were evaluated and considered structurally adequate in calculation in 7.4.58 and 7.4.59. The Tables below list the individual EC 25 Load Conditions and summarize EC 25 as reported in the calculation and with the PS adjusted for 0.0 ∆P NO.

Table I-219 - Individual Support LC Contributions Pipe Support 8332 X-213A

EC		DW lbs	Thermal lbs	SSE lbs	External Dynamic lbs	Design lbs
1 DW+TH+SSE+SRV	+	0	0	30	719	599
	-	150	30	30	750	960
2 DW+TH+0.0 ∆P PS	+	0	0	-	530	380
	-	150	30	-	390	570
3 DW+TH+SSE+DBA CO	+	0	0	30	1140	1020
	-	150	30	30	1140	1350
4 DW+TH+SSE+SRV+1.7 ∆P PS NO	+	0	0	30	809	689
	-	150	30	30	850	1060
4 DW+TH+SSE+SRV +0.0 ∆P PS Accident	+	0	0	30	1249	891
	-	150	30	30	1140	846
4 DW+TH+SSE+SRV +0.0 ∆P PS NO	+	0	0	30	1307	1026
	-	150	30	30	1183	867
5 DW+TH+SSE+SRV+CH	+	0	0	30	949	1047
	-	150	30	30	989	1199
Rated Support Load	+	1340				
	-	1730				

Table Notes

1. EC4 - 0.0 ∆P PS Accident and NO are calculated by SRSS of the individual Dynamic Load Conditions summed with the Static Load Conditions:

   DW+TH = -150/ -180 lbs

   SRV = 719/ -750 lbs

   SSE = 30/ -30 lbs

   PS1 = 530/ -390 lbs

   $$\text{EC 25:} = +\mathrm{DW} + \mathrm{TH} + \sqrt{(PS)^2 + SRV^2 + SSE^2}$$

   $$\text{EC 25:} = +\mathrm{DW} + \mathrm{TH} - \sqrt{(PS)^2 + SRV^2 + SSE^2}$$

2. Event Combinations are combined as listed in Reference: 7.4.58 Page 2 of 2.

Table I-220 - Individual Support LC Contributions Pipe Support 8333 X-213B

EC		DW lbs	Thermal lbs	SSE lbs	External Dynamic lbs	Design lbs
1 DW+TH+EQ+SRV	+	0	0	30	1229	1109
	-	150	30	30	1280	1490
2 DW+TH+0.0 ΔP PS	+	0	0	-	530	380
	-	150	30	-	390	570
3 DW+TH+EQ+DBA CO	+	0	0	30	1140	1020
	-	150	30	30	1140	1350
4 DW+TH+EQ+SRV+1.7 ΔP PS NO	+	0	0	30	1320	1200
	-	150	30	30	1380	1590
4 DW+TH+EQ+SRV +0.0 ΔP PS Accident	+	0	0	30	1759	1189
	-	150	30	30	1670	1518
4 DW+TH+EQ+SRV +0.0 ΔP PS NO	+	0	0	30	1817	1213
	-	150	30	30	1713	1532
5 DW+TH+EQ+SRV+CH	+	0	0	30	1460	1340
	-	150	30	30	1520	1730
Rated Support Load	+	1340				
	-	1730				

Table Notes

1. EC4 - 0.0 ΔP PS Accident and NO are calculated by SRSS of the individual Dynamic Load Conditions summed with the Static Load Conditions:

   DW+TH = -150/ -180

   SRV = 719/ -750 lbs

   SSE = 30/ -30

   PS1 = 530/ -390

   $$\text{EC 25} := +\text{DW} + \text{TH} + \sqrt{PS^2 + SRV^2 + SSE^2}$$

   $$\text{EC 25} := +\text{DW} + \text{TH} - \sqrt{PS^2 + SRV^2 + SSE^2}$$

2. Event Combinations are combined as listed in Reference: 7.4.58 Page 2 of 2.

Note that the original support designs including those by TES met Service Level A for design loading conditions. The new PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, any increase in support loads is bounded by the increase in Allowable Stress Value. However, using a less conservative methodology to combine dynamic load conditions demonstrates that the supports meet rated design load for 0.0 ΔP PS NO.

X-213A/B PIPE PENETRATION REVIEW

The torus shell penetration X-213A/B was evaluated based on the internal and external piping loads plus the torus shell stress results previously calculated from the DISTRES run [7.4.2 & 7.4.18].

X-213A

EC 15 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results and EC21 the maximum free shell stresses. Therefore, only EC 15/21 was evaluated and reported. Review the previous results and determine if the assumption that the EC 15/21 is bounding still applies (Table I-221 to Table I-224).

Table I-221 - Reported Penetration Stress Results X-213A

X-213A	Location	Stress psi	Reported psi	Reconciled (1) psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	15882	$1.5S_{MC}$ = 28,900	33,000	2.08
P_L	Torus Shell at Reinforcing Pad	11727	$1.5S_{MC}$ = 28,900	33,000	2.08
P_M	Nozzle	11773	$1.0S_{MC}$ = 19,300	22,000	1.87

Table Notes:

1. Reconciled allowable stress is from Section 2.13 Table 11.
2. Reported stresses were from 7.4.53 Page 21 and 24 of 31.

Table I-222 - Reported Individual Penetration Loads X-213A

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	230	0	0	0	0	60
TH	-34	0	0	0	0	-1590
EQ	20	120	60	2200	1230	940
SRV	2363	481	0	0	0	3821
CO	1007	3721	0	0	0	32698
CH	394	633	0	0	0	5200
PS1 (0.0 ΔP) Accident	679	927	0	0	0	11376
PS2 (1.7 ΔP) Accident	184	206	0	0	0	1496

Table I-223 – PS Load Adjusted for 0.0 ΔP NO X-213A

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ΔP) Accident	679	927	0	0	0	11376
PS1 (0.0 ΔP) Normal Operation	754	1029	0	0	0	12627

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].

Table I-224 - Adjusted ECs – Forces and Moments X-213A

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	3041	1234	60	2200	1230	11611
16 Reported	N+TH+0.0 ΔP PS	943	927	0	0	0	13026
16 Adjusted	N+TH+0.0 ΔP PS	950	1029	0	0	0	14157
21	N+TH+SSE+CO	1291	3841	60	2200	1230	35288
25 Reported	N+TH+SSE+SRV+1.7 ΔP PS	2831	807	60	2200	1230	7907
25 Adjusted	N+TH+SSE+SRV+0.0 ΔP PS	2676	1142	60	2200	1230	14756
EC25 0.0 ΔP PS/EC 15		0.95	0.93	1.00	1.00	1.00	1.27
Average - EC25 0.0 ΔP PS NO/ EC 15		0.96			1.09		

Table Notes:

1. Reported loads were from 7.4.53 Page 11 of 31.
2. The Load Condition Adjustment Factor revise the External Piping 0.0 ΔP PS Accident Condition for NO is 1.11 [Section 5.1 Table 13].
3. 0.0 ΔP PS Accident and NO are calculated by SRSS of the individual Dynamic Load Conditions summed with the Static Load Conditions:

$$\text{EC 25} := |\mathrm{DW} + \mathrm{TH}| + \sqrt{PS^2 + SRV^2 + SSE^2}$$

4. Average forces and moments for EC25 0.0 ΔP PS NO and EC 15 are compared. The larger average ratio of 1.09 will be used for adjustment of penetration stresses under EC25 0.0 ΔP PS NO.

Based on a review of the TABLE I-224- Adjusted EC – Forces and Moments, EC 25 is the bounding EC for 0.0 ΔP NO. Therefore, the local membrane stress for the torus shell and nozzle stress at the penetration will be adjusted for 0.0 ΔP NO by factoring the stress results by 1.09 as discussed above.

The penetration stress is updated in TABLE I-225. The penetration is adequate for continued service at 0.0 ΔP NO.

Table I-225 - Updated Penetration Stress Results X-213A

X-213A	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	17311	$1.5S_{MC}$ = 28,900	33,000	1.91
P_L	Torus Shell at Reinforcing Pad	12782	$1.5S_{MC}$ = 28,900	33,000	2.58
P_M	Nozzle	12833	$1.0S_{MC}$ = 19,300	22,000	1.71

X-213B

EC 15 was considered by TES to be controlling for the Penetration Evaluation based on the pipe stress results the maximum free shell stresses. Therefore, only EC 15 was evaluated and reported. Review the previous results and determine if the assumption that the EC 15 is bounding still applies (Table I-226 to Table I-229).

Table I-226 – Reported Penetration Stress Results X-213B

X-213B	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	16088	$1.5S_{MC}$ = 28,900	33,000	2.05
P_L	Torus Shell at Reinforcing Pad	16557	$1.5S_{MC}$ = 28,900	33,000	2.05
P_M	Nozzle	11774	$1.0S_{MC}$ = 19,300	22,000	1.87

Table Notes:

1. Reconciled allowable stress is from Section 5.1 Table 13.
2. Reported stresses were from 7.4.53 Page 28 and 31 of 31.

Table I-227 - Reported Individual Penetration Loads X-213B

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
DW	230	0	0	0	0	60
TH	34	0	0	0	0	1590
EQ	20	120	60	2200	1230	940
SRV	4017	818	0	0	0	6496
CO	1007	3721	0	0	0	32698
CH	394	633	0	0	0	5200
PS1 (0.0 ΔP) Accident	679	927	0	0	0	11376
PS2 (1.7 ΔP) Accident	184	206	0	0	0	1496

Table I-228 - PS Load Adjusted for 0.0 ΔP Normal Operation X-213B

Load Conditions	Force lbs			Moment in-lbs		
	Fx	Fy	Fz	Mx	My	Mz
PS1 (0.0 ΔP) Accident	679	927	0	0	0	11376
PS1 (0.0 ΔP) Normal Operation	754	1029	0	0	0	12627

Table Notes:

1. 0.0 ΔP PS Accident Condition Loading for External Piping - Adjustment Factor for Normal Operation is 1.11 [Section 5.1 Table 13].

Table I-229 - Adjusted EC – Forces and Moments X-213B

Event Combination	Load Conditions	Force lbs			Moment in-lbs		
		Fx	Fy	Fz	Mx	My	Mz
15	N+TH+SSE+SRV+CH	4695	1571	60	2200	1230	14286
16 Reported	N+TH+0.0 ∆P PS	943	927	0	0	0	13026
16 Adjusted	N+TH+0.0 ∆P PS	1018	1029	0	0	0	14277
21	N+TH+SSE+CO	1291	3841	60	2200	1230	35288
25 Reported	N+TH+SSE+SRV+1.7 ∆P PS	4485	1144	60	2200	1230	10582
25 Adjusted	N+TH+SSE+SRV+0.0 ∆P PS	4351	1320	60	2200	1230	14876
EC25 0.0 ∆P PS/EC 15		0.93	0.84	1.00	1.00	1.00	1.04
Average - EC25 0.0 ∆P PS NO/ EC 15		0.92			1.01		

Table Notes:

1. Reported loads were from 7.4.53 Page 25 of 31.
2. The Load Condition Adjustment Factor revise the External Piping 0.0 ∆P PS Accident Condition for NO is 1.11 [Section 5.1 Table 13].
3. 0.0 ∆P PS Accident and NO are calculated by SRSS of the individual Dynamic Load Conditions summed with the Static Load Conditions:
4. EC 25:= $|\mathrm{DW} + \mathrm{TH}| + \sqrt{PS^2 + SRV^2 + SSE^2}$
5. Average forces and moments for EC25 0.0 ∆P PS NO and EC 15 are compared. The larger average ratio of 1.09 will be used for adjustment of penetration stresses under EC25 0.0 ∆P PS NO.

Based on a review of the Table I-229- Adjusted EC – Forces and Moments, EC 25 is the bounding EC for 0.0 ∆P NO. However, the local membrane stress for the torus shell and nozzle stress at the penetration does not require adjustment for 0.0 ∆P NO as EC 15 is generally bounding

Thus, the penetration stress is updates as in Table I-230. This penetration is adequate.

Table I-230 - Updated Penetration Stress Results X-213B

X-213B	Location	Stress psi	Reported psi	Reconciled psi	Allowable/ Actual
P_L	Torus Shell at Nozzle	16088	$1.5S_{MC}$ = 28,900	33,000	2.05
P_L	Torus Shell at Reinforcing Pad	16557	$1.5S_{MC}$ = 28,900	33,000	2.05
P_M	Nozzle	11774	$1.0S_{MC}$ = 19,300	22,000	1.87

X-213A/B BRANCH LINE REVIEW

No Branch exists in the penetration [7.4.53 Page 1 of 1].

X-213A/B VALVE REVIEW

The stresses for partial valves/pump in the penetrations are shown in Table I-231.

Table I-231 - Stresses in Valves/Pump X-213AB

Valve/Pump Designation	Maximum Stress	1.2 S_H	Allowable/Maximum Stress
X-213A 3" globe valve	21777	20520	0.94
X-213A 3" globe valve	10796	20520	1.90
X-213A 1" globe valve	1460	20520	14.05
X-213B 3" globe valve	21776	20520	0.94
X-213B 3" globe valve	12556	20520	1.63
X-213B 1" globe valve	1459	20520	14.05

Table Notes:

1. Reference: 7.4.53 Page 1-2 of 6.
2. All maximum stress from LC 3.

TES concluded that the Torus Drain Lines associated with Penetrations X-213A/B are not used during plant operation and the valves do not have to meet the 1.2 S_H allowable stress values [7.4.53 Page 8 of 8].

Table I-232 - X-213A/B Summary of Results Table

Location	EC	Load Condition	Allowable/ Actual
Piping	21	DBA CO	1.32
X-213A Penetration	25	0.0 ΔP PS NO	1.10
X-213A Penetration	25	0.0 ΔP PS NO	1.32
Valves	21	DBA CO	0.94

Small Bore Torus Attached Piping

The PUAR for the TAP evaluated both Large and Small Bore piping [7.3.3]. The small bore TAP systems are X-203B Oxygen Analyzer, X-206ABCD Liquid Level Indicator Piping, X-217 HPCI Piping, X-221 Vacuum Pump Discharge Piping, X-222 Condensate Drain Piping, X-206A1/A2, B1, C1/C2, D1 Torus Level Piping and X-248ABC Torus Water Sampling Piping.

As stated in the TR-5321-2 TAP PUAR Appendix 1, based on TES experience gained with the large bore piping analysis, the DBA CO Load Condition was the most severe Mark I Program Load Condition for torus attached piping with few exceptions [7.3.3]. Therefore, it was decided by TES to limit analysis of small bore piping to DBA CO with the consideration of seismic, thermal and weight [7.3.3 Appendix 1]. The results for the 5 small bore TAPs as listed was based on EC 21 in Table I-233 [7.3.3 Table 3-2]. The individual calculations for the small bore TAP systems being reviewed are:

1. Penetration X-203B R0, "Torus Attached Piping Analysis," September 1983 [7.4.33]
2. Penetration X-206ABCD R0, "Torus Attached Piping Analysis," September 1983 [7.4.35]
3. Penetration X-221 and X-217 R2, "Torus Attached Piping Analysis," October 1983 [7.4.50]
4. Penetration X-222 R1, "Torus Attached Piping Analysis," September 1983 [7.4.51]

Table I-233 - Reported Small Bore TAP Pipe Stress

System Name	Penetration Name	Maximum Stress psi	Allowable Stress psi	Maximum Stress Location
Oxygen Analyzer	X-203 B	11,110	36,000	Node 1
Liquid Level Indicator	X-206A, B, C & D	25,738	36,000	Node 1
High Pressure Coolant Injection	X-217	25,545(2)	36,000	Node 28
Vacuum Pump Discharge	X-221	19,538	36,000	Node 24
Condensate Drain	X-222	18,162	36,000	Node 58

Table Notes:

1. Reference: 7.3.3 Table 3-2.
2. The analysis of penetration X-217 is enveloped by the analysis of X-221. The pipe stress and support loads for X-217 are small [7.4.50 Page 1-2 of 2]. The listed maximum stress for X-217 was not referenced.

Since the original TES PUAR TR-5321-2 and Mk I Program were completed, new small bore piping systems were added at TAP Penetrations X-206A1/2, X-206B1, X-206C1/2, X-206D1, X-248A/B/C. Based on Entergy JAF drawings, the new small bore TAP systems are of similar construction as X-206 A, B, C & D [7.7.6 to 7.7.10]. The location of maximum stress for the X-206 A, B, C & D TAP was located at the Penetration attachment to the Torus Shell [7.4.35 Page 1 of 1]. The penetration stress envelopes the pipe stresses at all other locations.

All the additional penetrations X-206A1/2, X-206B1, X-206C1/2, X-206D1, X-248A/B/C are of similar configuration to X-206 A, B, C & D. That is, the Torus penetration is a 1" 6000# Socket Weld coupling with ¾" reducer insert and cantilevered pipe segment to ¾" Socket Weld Globe Valve [7.4.60]. Sustained and Occasional pipe stress values (8766 psi maximum) are also on par with the X-206 A, B, C & D results [7.4.61]. Downstream of the globe valve some of the originally capped system configuration have ½" OD SS instrument tubing attached. As discussed above, TES determined that the DBA CO loading was considerably more severe than the other Mk I Program DBA loads. The tube is flexible compared to the ¾" pipe. This DBA CO loading is cyclic and tends to excite the cantilevered valve mass which stresses the associated penetration. The piping configuration is not as sensitive to the DBA PS which is quasi-static and only one load cycle.

Based on the discussion above the new penetrations X-206A1/2, X-206B1, X-206C1/2, X-206D1, X-248A/B/C are enveloped by the X-206 A, B, C & D calculation.

SMALL BORE TAP PIPE STRESS

The TES PUAR Attachment 1 discussed the small bore piping evaluation and limited it to EC 16. That is, for small bore TAP EC 16 envelopes all other Mk I Program ECs. Therefore, to determine the maximum EC 25 0.0 ΔP NO pipe stress from EC 21 application of the Load Condition Adjustment Factor of 1.11 for the 0.0 ΔP PS ↓ Download Phase is applied to the dynamic load portion of EC 16.

Table I-234 - Small Bore Pipe Stress at 0.0 ΔP NO

Stress psi	P+N	EC21	SRV + DBA CO	0.0 ΔP PS NO	EC 25 NO	EC25NO/ EC21	Allowable 2.4 S_H	Allowable/ Actual
X-203B	4771	11110	6339	7036	11807	1.06	41040	3.48
X-206 (X-248)	11476	25738	14262	15831	27307	1.06	41040	1.50
X-221 (X-217)	2368	19538	17170	19059	21427	1.10	41040	1.92
X-222	5734	18162	12428	13795	19529	1.08	41040	2.10

Table Notes:

1. References: 7.4.33 Page 1 of 1, 7.4.35 Page 1 of 1, 7.4.50 Page 1 of 1, and 7.4.51 Page 1 of 1.
2. SRV is not concurrent with CH/CO due to loss of RPV pressure with DBA events [Section 2.10].
3. Reconciled allowable stress is from Section 2.13 Table 11. S_H is increased from 15,000 to 17,100 psi.
4. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase of 1.11 is applied to EC 21 to obtain the 0.0 ΔP NO EC 25 results [Section 5.1 Table 13].
5. X-206 (X-248) includes penetrations X-206 A, B, C & D, X-206 A1/2, X-206 B1, X-206 C1/2, X-206 D1 and X-248 A, B & C.

SMALL BORE TAP PIPE SUPPORT REVIEW

The small bore TAP EC 21 support loads are reported for each of the piping systems. The load conditions were combined by signed summation. The dynamic contribution was not combined by SRSS. Adjust EC 21 support loads for EC 25 NO using a static load condition summation with sign (DW + TH) and SRSS of the dynamic load combinations (DBA CO, SSE) to reduce conservatism. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase of 1.11 is applied to EC 21 to obtain the 0.0 ΔP NO EC 25 results [Section 5.1 Table 13].

1. The maximum X-203B Mk I DBA CO pipe support load is 89 lbs with a maximum total EC 21 support load of 338 lbs. Using a Static load condition summation with sign (DW + TH) and SRSS of the dynamic load combinations (DBA CO, SSE) with an additional 10 lbs (1.11 x 89) to represent EC 25 NO is 348 lbs. The total represents a 3% or 10 lbs increase in support load which is not of significance.

2. The maximum X-206 A, B Mk I DBA CO pipe support load is 69 lbs with a maximum total EC 21 support load of 99 lbs. Using a Static load condition summation with sign (DW + TH) and SRSS of the dynamic load combinations (DBACO, SSE) with an additional 8 lbs (1.11 x 69) to represent EC 25 NO is 71 lbs. This represents a support load decrease.
3. The maximum X-221/ X217 A, B Mk I DBA CO pipe support load is 259 lbs with a maximum total EC 21 support load of 459 lbs. Using a Static load condition summation with sign (DW + TH) and SRSS of the dynamic load combinations (DBACO, SSE) with an additional 29 lbs (1.11 x 259) to represent EC 25 NO is 418 lbs. This represents a support load decrease.
4. The maximum X-221/ X217 A, B Mk I DBA CO pipe support load is 160 lbs with a maximum total EC 21 support load of 230 lbs. Using a Static load condition summation with sign (DW + TH) and SRSS of the dynamic load combinations (DBACO, SSE) with an additional 18 lbs (1.11 x 160) to represent EC 25 NO is 220 lbs. This represents a support load decrease.

Note that the original support designs including those by TES generally met Service Level A for design loading conditions. The NO PS EC25 is Service Level B with a 1/3 increase in Allowable Stress Value compared to Service Level A [7.2.1 Table 5-2 & 7.5.5, Subsection NF, Table NF-3312.1(b)-1]. Therefore, the increase in support loads is bounded by the increase in Allowable Stress Value.

The small bore TAP support loads are adequate for continued service at 0.0 ΔP NO.

SMALL BORE TAP PIPE PENETRATION REVIEW

The torus shell penetrations for the small bore TAPs were evaluated based on the external piping loads using EC21. Internal loads were determined to be negligible by TES. The pipe penetration stress results are listed below Table I-235. As calculated in Table I-234, to obtain EC25 NO from EC21 the Load Condition Adjustment Factor of 1.11 will be applied.

Table I-235 - Reported Small Bore Pipe Penetration Stress Results

Pipe Stress psi	Stress	Updated Stress	Reported	Reconciled	Allowable/ Maximum
X-206 A, B, C & D X-206 A1/2 X-206 B1 X-206 C1/2 X-206 D1 X-248 A, B & C	3976	4360	$1.5S_{MC}$ = 28,900	33,000	7.57
X-203B	3976	4360	$1.5S_{MC}$ = 28,900	33,000	7.57
X-221(X-217)	2150	2358	$1.5S_{MC}$ = 28,900	33,000	14.00
X-222	2150	2358	$1.5S_{MC}$ = 28,900	33,000	14.00

Table Notes:

1. Reported stresses were from 7.4.35 Page 8 of 9, 7.4.33 Page 6 of 7, 7.4.50 Page 7 of 7, 7.4.51 Page 7 of 7.
2. Reconciled allowable stress is from Section 2.13 Table 11. S_H value is increased from 15,000 to 17,100 psi.
3. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase of 1.11 is applied to EC 21 to obtain the 0.0 ΔP NO EC 25 results [Section 5.1 Table 13].

Large margins exist for each of the small bore TAP penetration pipe stress. Therefore, the penetrations will be adequate under 0.0 ΔP PS normal operation condition.

SMALL BORE TAP BRANCH LINE REVIEW

No branch lines were analyzed for the small bore TAPs.

SMALL BORE TAP VALVE REVIEW

The maximum valves/pump stresses in each small bore TAP are shown in Table I-236. As calculated in the previous tables the Load Condition Adjustment Factor of 1.11 is applied to EC 21 valve stresses to obtain EC25 NO stress results.

Table I-236 - Small Bore TAP Valves/Pump Stresses

Valve/Pump	Maximum Stress psi	Updated Maximum Stress psi	Allowable 1.2 SH psi	Allowable/ Actual
X-203 B	10915	11970	20520	1.71
X-206 A, B, C & D 1"-VGS-60B	14337	15723	20520	1.31
X-221 (X-217) 2"-VGS-60B	9144	10028	20520	2.05
X-222 2"-VKS-60A	15495	16993	20520	1.21

Table Notes:

1. Reference: 7.4.33 Page 1 of 8, 7.4.35 Page 1 of 17, 7.4.50 Page 1 of 8 & 7.4.51 Page 2 of 7.
2. Reconciled allowable stress is from Section 2.13 Table 11. S_H Value is increased from 15,000 to 17,100 psi
3. The Load Condition Adjustment Factor for the 0.0 ΔP PS ↓ Download Phase of 1.11 is applied to EC 21 to obtain the 0.0 ΔP NO EC 25 results [Section 5.1 Table 13].

Large margins exist for each of the small bore TAP valve stress. Therefore, the valves will be adequate under 0.0 ΔP PS normal operation condition.

Table I-237 - Small Bore Tap Summary of Results Table

TAPs	Location	EC	Load Condition	Allowable/ Actual
X-203B	Piping	25	0.0 ΔP PS NO	3.48
	Penetration	25	0.0 ΔP PS NO	7.57
	Valve	25	0.0 ΔP PS NO	1.71
X-206 A, B, C & D X-206 A1/2 X-206 B1 X-206 C1/2 X-206 D1 X-248 A, B & C	Piping	25	0.0 ΔP PS NO	1.50
	Penetration	25	0.0 ΔP PS NO	7.57
	Valve	25	0.0 ΔP PS NO	1.31
X-221 (X-217)	Piping	25	0.0 ΔP PS NO	1.92
	Penetration	25	0.0 ΔP PS NO	14.00
	Valve	25	0.0 ΔP PS NO	2.05
X-222	Piping	25	0.0 ΔP PS NO	2.10
	Penetration	25	0.0 ΔP PS NO	14.00
	Valve	25	0.0 ΔP PS NO	1.21

J. CONTAINMENT DP FEASIBILITY STUDY

Unpublished Report
CONTAINMENT DP FEASIBILITY STUDY
Report # JAF-RPT-13-00012 Rev.0
by Nicholas Celia, P. E.

Contents

1.0 Purpose
2.0 Program Background
3.0 Method and Load Combinations
4.0 Plant Changes Since Mark 1 Program Analysis and Effect on Loads
    4.1 ECCS Suction Strainers
    4.2 Two inch increase in water level
    4.3 Six percent power uprate
    4.4 Piping modifications

5.0 Important Previous Reports and Analysis Used in this Study

6.0 Calculation of Zero Delta P Loads
    6.1 Download Pressure for 0 delta P Evaluation
    6.2 Upload Pressure for 0 delta P Evaluation
    6.3 LOCA Jet and LOCA Bubble Loads
    6.4 Vent Header Impact and Drag
    6.5 Froth Loads
    6.6 Pool Fallback Loads
    6.7 SRV Loads

7.0 Structures Acceptable in Reference 1 Study

8.0 Evaluation of Overstress Conditions From Reference 1
    8.1 Support System Welds
    8.2 Column and saddle anchors
    8.3 Internal Spray Header Supports
    8.4 Monorail
    8.5 Catwalk

9.0 Evaluation of New ECCS Suction Strainers
    9.1 Pool Fallback Loads
    9.2 LOCA Jet and LOCA Bubble Loads
    9.3 SRV Loads
    9.4 CO and CH Loads
    9.5 Conclusion for ECCS Suction Strainers at 0 delta P

10.0 Attached Piping
11.0 Conclusions and Recommendations
12.0 References

Nicholas Celia, P.E. Consulting Engineer

1.0 Purpose

Presently, the JAFNPP is required to maintain a positive pressure differential between the drywell and wetwell (delta P) as a condition for normal operation of the plant.

The purpose of this work is to study the feasibility of removing the delta P requirement. If this change appears to be feasible, detailed analysis will be required to confirm the finding.

2.0 Program Background

Testing done by General Electric in the early 1970's identified loads in the suppression pool (torus) that would result from a large pipe break in the drywell, and had not previously been identified. The Mark I Torus Program was begun in 1974 to study this load, and the stresses induced on structure and piping. At that same time, plant experience with SRV discharge loads showed that these loads were greater than originally thought, so these were also made part of the Mark I Torus Program.

The Mark I Program was addressed in two parts. The Short Term Program addressed the initial period of the large break accident, where rapidly expanding steam in the drywell forced air and steam into the wetwell causing high downward pressure on the Torus shell, followed by rapid upward motion of the pool water - this initial break load became known as the pool swell load.

Early testing showed that the pool swell load could be mitigated by pressurizing the drywell, which reduced the water volume inside the downcomers, and reduced the back pressure resisting the air/steam discharge. This delta P condition was imposed on all the Mark I plants as a requirement for continued operation.

After the Short Term program was complete and delta P was installed, other loads related to the large break and smaller break accidents were identified, - some of these loads produced stresses that exceeded those calculated for the pool swell load. These other loads controlled almost all of the maximum stresses.

Because the delta P loads were no longer controlling, there have been questions of whether or not the delta P requirement could be relaxed or completely eliminated. Complete elimination of delta P is the subject of this study.

3.0 Method and Load Combinations

There has been continued interest in eliminating delta P for many years now. I have performed studies for Pilgrim, Vermont Yankee, Millstone,and JAF in the past. I also performed extensive calculations for the Millstone Plant, which were nearly complete when the plant was shut down.

All of the early studies showed that eliminating delta P would produce high overstress in the Torus support system. However, detailed analysis for Vermont Yankee and Millstone identified several conservatisms in these areas which reduced the overstress conditions. In addition, I have worked with the NRC consultant who provided the adjustment factor for the pool swell loads analysis for the Mark I Program, and now have more accurate, and lower, loads than were used in these earlier 0 delta P studies.

This present work will use the early JAF study, and modify it to eliminate the conservatisms found by later analysis, and will include load reductions provided by the NRC consultant.

In addition, this new study will include any plant changes made since the original study was done (1994). These include changes to pool water level, power uprate, and the addition of ECCS Suction Strainers. Several piping changes have been made for piping attached to the Torus, but evaluation of piping systems is not a part of this present study. However, some results of previous studies of attached piping at 0 delta P are included in Section 10.

Load Combinations - The Mark 1 Program specified 26 load combinations with allowable stresses that were considered (ref 11, page 114).

Of these 26, 6 included DBA Pool Swell loads - these are the only load cases affected by a change to 0 delta P.

Of those 6, simple bounding methods reduce the number to 2. They are :

L.C. #16	0 delta P + Normal (N) Loads	Evaluated to Level A stresses
L.C. #25	0 delta P + SRV + Seismic + N	Evaluated to Level C Stresses
	(Seismic and SRV can be combined by SRSS)	

These are the 2 cases that are considered in this report.

A more detailed discussion of the bounding method can be found in reference 1, page 14.

4.0 Plant Changes Since the end of the Mark 1 Program, and Effect on Loads

4.1 ECCS Suction Strainers

New, larger suction strainers have replaced the original units (reference 5, pages 13-21). Loads on these strainers for full delta P are shown in reference 5 - changes for 0 delta P operation are shown in section 9 of this report.

New RHR strainers now span 2 bays, and are composed of multiple 45 inch discs (penetrations X225A/B).

New Core Spray strainers are now approximately 12 feet long and also made up of 45 inch discs - they are mounted horizontally and supported by the ring girders (penetrations X227A/B).

The new HPCI strainer (penetration X226) is approximately 5 feet long and made up of 40 inch discs. It is mounted axially on the penetration.

The new RCIC strainer (penetration X224), is approximately 1.5 feet long with 2, 18 inch discs. It is also mounted axially on the penetration.

The new ECCS suction strainers will impose different loads on the Torus shell penetrations, and the attached external piping. Piping is not addressed in this study, but must be evaluated in the future. We would expect that loads for the RHR and Core Spray strainers will not increase piping loads, since they are well supported inside the Torus. Loads for HPCI and RCIC will probably increase, but these are much smaller units

4.2 Torus Water Level Increase

The maximum water level in the Torus was increased by 2 inches. This change affects all of the pool swell-related loads by a small amount. These are calculated in reference 16, and are shown in section 6.0 of this report.

4.3 Power Uprate

Plant power has been increased by 6%. The main affect of this is to increase the SRV discharge pressure, which increases loads on the SRV discharge line, supports, and quencher, as well as the discharge pressure into the Torus. These changes are addressed in reference 17, and are listed in section 6.7 of this report, to the extent that they affect Torus loading.

Piping Modifications

Several modifications have been made to Torus attached piping, outside of the Torus. Piping outside the Torus is not included in the scope of this study, but work done previously in reported in section 10.0.

5.0 Important Previous Reports and Analysis Used in This Study

5.1 JAF, Zero Delta P Study, 1994 (Ref 1) In 1994, an early study was done to determine the effects of removing delta P at JAF. That study was based primarily on the Mark I Program analysis, and conservatively adjusted for a 2 inch increase in Torus water level. The results of that study were not encouraging, due to several conservatisms and assumptions, where we now have better information. That report will be used as the basis of this present work, to the extent it applies. In addition, the affects of power uprate and the larger ECCS suction strainers are considered here.

5.2 Vermont Yankee Torus Support System Analysis, 1994-5 (Ref 2) VY also performed preliminary analysis to evaluate the possibility of eliminating delta P, and subsequently performed a detailed finite element analysis of highly stressed parts of the supports. This finite element work identified several conservatisms in the Mark I Program analysis and produced much lower stresses that eliminated the overstress conditions. Results of that work are discussed in this present analysis

5.3 JAF, Load and Stress Reports for the ECCS Suction Strainers, 1998, (Ref 5 and 8) In 1998, ECCS Suction Strainers were installed in the JAF Torus. These are large structures that present a large target for pool swell loads. Stresses in these structures at 0 delta P will be addressed in this report.

6.0 Calculation of Zero Delta P loads

For purposes of this study, we will calculate the increase in the full delta P load used in the Mark 1 Program to account for the change for 0 delta P operation. In addition, we will adjust the 0 delta P loads to account for the fact that the program only ran a single test at the 0 delta P condition (a statistical bump factor is required). We also will adjust the 0 delta P load to account for the 2 inch increase in pool water level, done at JAF since the Mark 1 Program, and will consider the effects of power uprate.

Reference 12 provides sensitivity data that shows the effects of changes in water level for several different loads - all of this data is for the full delta P condition. In this work, we will use the full delta P relations as bounding for the 0 delta P condition. The reason for this assumption follows.

We know that longer downcomer clearing times produce higher up and down loads. Applying delta P reduces these loads because it reduces downcomer clearing time, which then reduces the back pressure in the downcomer. Therefore, downcomer clearing time is a measure of the load that is produced.

Because the water leg in the downcomer is short for full delta P, a 2 inch water level change will be more important (on a percentage basis) than a 2 inch water level change at 0 delta P, where the water leg is much longer. Reference 6, figure A-761 shows the downcomer water clearing velocity is 8.5 ft/sec and clearing time is .048 sec for full delta P at JAF. A 2 inch change in water level increases clearing time by 2/(8.5x12)= .02 sec, which is a 42% increase. At 0 delta P, the dowmcomer clearing velocity is 31 ft/sec at .142 sec. (reference 6, figure A762). Changing the water level by 2 inches changes the time for downcomer clearing by 2/(31x12)=.005 sec, or 3.5%.

We interpret this to mean that the effect of the 2 inch water level change is much less at 0 delta P than at full delta P, on a percentage basis, and it will be conservative to use the load increase at full delta P for 0 delta P. We will do that here.

Power uprate is also considered here, but has no affect on the calculations. The effect of power uprate on pool swell pressures was reviewed by GE in reference 19, where it was concluded that any increases were smaller than conservatisms in the computer codes used in the calculation.

Nicholas Celia, P.E. Consulting Engineer

The effect of power uprate on SRV discharge pressure, including discharge loads into the Torus is addressed in reference 17, which concludes that conservatisms in the Mark 1 SRV analysis by Teledyne are sufficient to account for the power uprate changes.

The intent of this evaluation is to provide factors that can be applied to the Mark 1 analysis to determine feasibility of 0 delta P operation. Because of this, some of these factors may be approximate or conservative, so are not intended for detailed analysis.

6.1 Download Pressures on the Torus Shell for 0 delta P Evaluation

The download pressure at 0 delta P used in the Mark 1 Program analysis was 14.54 psi @ .295 sec, as shown in reference 15, page 55.

This number includes factors, required by the NRC, to account for the statistical uncertainty of the data. These factors were calculated on a 4 test sample for the operating delta P condition.

In this analysis, because 0 delta P will be the operating condition, and only 1 quarter scale test was done, it is necessary to recalculate this statistical factor.

Several years ago, when the full set of Mark I Program test data was still available, I contacted the same consultant who did the statistical analysis for the NRC, and asked him to perform a calculation for JAF for use for normal operation at 0 delta P. He reported his analysis in reference 7.

For Download, the NRC adjustment factor was given at $2.3 \times 10^{-5} P_m$ (later reduced to $2.0 \times 10^{-5} P_m$), which produced a pressure increase of 1.63 psi for JAF.

Calculations in reference 7 for JAF operating at 0 delta P show a factor of $2.91 \times 10^{-5} P_m$. The new download adjustment for 0 delta P to account for having only a single test is therefore:

(2.91/2.3)1.63 = 2.06 psi, an increase of .43 psi or:

(.43/14.54)100 = 3%

The effect of the 2 inch water level increase is shown in reference 12, figure 3-30. The 2 inch change increases submergence at JAF from 50 to 52 inches (12.5 to 13 inches at quarter scale). Reference 12 shows this will increase download by 2.6%.

The downward load pressure is therefore;

14.54 (1.03)(1.026)=15.37 psi

6.2 Upload Pressure at 0 delta P

For upload, the calculation follows similar steps as for the download, except the adjustment is applied to the Torus airspace pressure.

The upload pressure used in the Mark 1 Program analysis for 0 delta P cases was 7.29 psi @.6 sec (reference 15, page 55).

The NRC adjustment to upward pressure was .215 P_m, which produced an upward pressure adjustment of 1.29 psi. This adjustment included 2 factors. A factor of .15 P_m was used to adjust for the geometry of the test facility, and a factor of .072 P_m was for the statistical adjustment (the .072 factor was later reduced to .065 because of other conservatisms).

Calculations in reference 7 showed that factor should be increased to .092 P_m for a single test. Therefore, the increase in upload pressure is:

$.092 - .072 = .02\ P_m$, and the new adjustment for upload becomes:

$(.215 + .02)\ P_m = .235\ P_m$

This increases the 1.29 psi upward pressure adjustment to :

$(.235/.215)1.29 = 1.41$ psi, or a .12 psi increase to account for a single test

The statistical adjustment to upward pressure for normal operation at zero delta P then becomes:

$7.29 + .12 = 7.41$ psi, and increase of:

$\{(7.41/7.29)-1\}100 = 1.6\%$

The adjustment for water level change is also shown in reference 12, figure 3-30, as for the download. A submergence change from 50 to 52 inches shows a change in upload of -2.1%, a load decrease.

As for download, power uprate has no effect, therefore, the changes in upload are +1.6% and -2.1%, which means the adjusted upward pressure for 0 delta P is:

$7.29\ (1.016)(.979) = 7.26$ psi

6.3 LOCA Jet and Bubble Forces

Accurate calculations for LOCA Jet and Bubble loads require running the LOCAFOR computer program, provided as part of the Mark 1 Program.

However, we know that LOCA Jet is bounded by LOCA Bubble, so we need not consider it in this evaluation.

In addition, we can estimate the increase in the LOCA Bubble force using data in the Vent Header Support Column analysis (reference 3).

The Vent Header Support Columns extend from the bottom of the Torus to the water level, near the center of the pool. Pages 11 and 14 of reference 3 show bubble forces on the support for both full and 0 delta P.

The ratio of these forces varies very little for each element, and is approximately 2.0 (slightly less for the highest force elements).

This factor is approximately the same as the factor relating maximum 0 delta P to full delta P downward loads from the test data, before adjustments (12.8/6.0) = 2.2. This supports the ratio above, since the LOCA Bubble is responsible for the maximum downward pressures.

Based on this, we will use a load ratio of 2.0 in this report to scale bubble loads to 0 delta P.

Actually, most of the submerged structures were analyzed at 0 delta P in the Mark 1 Program, so there is no need to adjust these.

6.4 Vent Header Impact and Drag at Zero Delta P

Vent header impact pressures at both full and 0 delta P are contained in reference 18 for JAF (pages 57 and 61). Most of the Mark 1 Program analysis conservatively used 0 delta P loads for all cases, but a few did not. For those cases, we will estimate the increased loads for 0 delta P based on a comparison of the average of the maximum 0 and full delta P pressures on the vent header.

At full delta P, the average of the maxima is:

(9.17+4.43+1.29+6.21+4.44+.74+8.31+9.89+3.53+7.24
+11.75+5.37+6.69)/13 = 6.1 psi

For 0 delta P, the average of the maxima is:

(15.4+3.47+3.17+6.27+2.4+1.24+11.49+8.93+6.02+8.7
+15.02+5.86+9.34)/13=7.49 psi

The average increase at 0 delta P is:
7.49/6.1=1.23, a 23% increase

In the Mark 1 Program, the NRC did not require the addition of a statistical factor to adjust any internal structural loads, including loads on the vent header.

Because of this, there is no basis to scale the load for a single test. The fact that there was no factor for 4 tests is interpreted to mean either that the data spread was small, or other conservatisms made an adjustment unnecessary.

For purposes of this work, we will use the same 1.6% increase for the statistical adjustment for vent header as for the uplift load.

The effect of the water level increase can be estimated from reference 12, figure 3-52, which shows the change in Vent Header impulse force (force x time) for different water levels. Using the right end of the curve (12.5 to 13 inches in quarter scale), the percent increase is:

(8-7.8)/7.8=2.6%

Nicholas Celia, P.E. Consulting Engineer

Power uprate has no effect, therefore,

Total increase in full delta P Vent Header impact and drag, for use at 0 delta P is:

Increase= (1.23)(1.016)(1.026) = 1.28 = a 28% increase

6.5 Froth Loads

Froth is a mixture of water and air, and affects structures above the pool. It is the result of 2 different sources, so has 2 different load definitions for different areas of the pool.

Froth 1 is the result of pool impact with the bottom of the vent header. It is related to the square of the velocity of the rising pool at the time of first contact (ref 9, page 10-4.3.5-1, and ref 13, page 67).

If we allow for a 2 inch increase in water level when reading the figures, the velocities for full and 0 delta P are:

Velocity at Bottom of Vent Header

	Time	Velocity	
Full delta P	.170	17.5	Ref 6, Figures a-840, A-844
0 delta P	.240	16.0	Ref 6, Figures A-842, A-846

Since the velocity at the bottom of the vent header at 0 delta P is less than for full delta P, the froth load at 0 delta P will be less than for full delta P.

There is no statistical adjustment for the froth load (as was the case for the vent header), and there is none for power uprate, therefore, froth 1 loads at full delta P can be used for 0 delta P also.

Froth 2 loads result from air bubble breakthrough when the pool is at its maximum elevation. It is related to the square of the velocity at maximum pool height (ref 9, pages 10-4.3.5-2 and 3). Reference 6, figures A752, 753, 754, and 757 show the pool displacements and velocities at the maximum pool height for full delta P. Figures A755 and A759 show maximum pool velocity and height for 0 delta P.

The pool velocities at the time of maximum pool height are:

	Max Pool Ht (ft)	Max Vel (ft/s)
Full Delta P	19.5	14.5
0 Delta P	20.5	12

Since the froth impingement load is related to the square of the impact velocity, the froth loads are related by:

Full Delta P $\propto (14.5)^2 = 210$

0 Delta P $\propto (12)^2 = 144$

The froth load at 0 delta P is 64% less than the froth load at full delta P.

As for froth 1, no adjustments are required for a single test, or power uprate.

For froth 2, the loads at 0 delta P are significantly lower than the loads at full delta P, so the full delta P loads can be used for 0 delta P analysis.

6.6 Fallback Loads

The only structures where pool fallback is important are the new ECCS suction strainers. These are a special case, and the loads are discussed in Section 9.1.

6.7 SRV Loads

Pressurizing the drywell opens the SRV line vacuum breaker and depresses the water leg in the SRV line by the same amount as in the downcomers. Because of this, the effect of 0 delta P operation must be considered for SRV loads

.6.7.1 SRV Blowdown Loads

T-Quenchers

SRV blowdown loads affect stress in the SRV line, supports, and quencher, including the ramshead. Reference 10, page 5 shows that the existing blowdown analysis was conservatively done at 0 delta P.

In addition, this analysis was done at a conservative pressure which is higher than the SRV line pressure after the Power Uprate (1145 psi vs 1140 psi).

Therefore, the SRV Blowdown Loads from the Mark I Program analysis are acceptable for 0 delta P operation, including the increased pressure due to power uprate

6.7.2 SRV Jet and Bubble Loads

SRV Jet Loads are the result of the water in the SRV line being discharged into the pool by the high discharge pressure in the line. Bubble loads are the result of air clearing from the discharge line immediately following water clearing.

At 0 delta P, the jet loads would show the greater change, since the increased water leg would result in higher velocities before clearing. The air clearing (bubble) loads would show a smaller change because the driving pressure in the discharge line would equal the pressure in the main steam line immediately on SRV actuation, so the longer clearing time would have no effect on air bubble pressure. This is different from the case of downcomer clearing, where delta P is applied to the downcomers to allow clearing of all water before the drywell pressure builds up. In the SRV line, the full pressure of the main steam line reaches the water instantly, so the effect of the depressed water level is minimized.

Analysis done in the Mark 1 Program always showed the bubble loads bounded the jet loads. In addition, the jet loads dissipate quickly, and only affect pressures within a few feet of the quencher arms - there are no structures this close to the quenchers.

Since the bubble loads will control, and these are not sensitive to water level changes in the SRV discharge line, we expect no significant change at 0 delta P.

Nicholas Celia, P.E. Consulting Engineer

This is consistent with data collected during in-plant SRV testing done by Teledyne. Measured bubble pressures were similar at JAF and Vermont Yankee, even though the water leg at VY is several times as long as it is at JAF.

7.0 Structures Acceptable in Reference 1 Report

Reference 1 evaluated most structures for normal operation at 0 delta P, but used conservative load factors. The reference 1 factors compare to the ones in this report as follows:

Comparison of Loads and Load Factors

	Ref 1	This Report
Download	17.4	15.37
Upload	7.94	7.26
Vent Hdr Impact	1.44x	1.28x
Froth 1	1.33x	1.0x
Froth 2	1.33x	1.0x
Fallback	not done	1.0x (approx)
LOCA Bubble	not done	2.0x (approx)

Comparison of the loads and load factors above show the earlier analysis is conservative in every case; therefore, the results from reference 1 are still valid in this analysis.

Reference 1 showed the following structures are acceptable for normal operation at 0 delta P, with the following conservative margins:

Torus shell	.79 x Code
Support columns and base joint	.84 x Code
Support saddles	.61 x Code
Earthquake restraints	<.5 x Code
VH/DC Intersection	.86 x Code
VH/VP Intersection	.96 x Code*
VH support columns	at Code*
DC tie bars	.5 x Code*
VH deflector	.6 x Code
Main Vent/DW intersection	.5 x Code (approx)
Ring Girder	at Code
SRV quencher and support	.7 x Code*
Catwalk**	
Vent Bellows	.5 x Allowable (approx)

Nicholas Celia, P.E. Consulting Engineer

We expect all stresses near Code allowables will be reduced with the less conservative loads and factors in this report.

* Evaluated at 0 delta P in the Mark 1 Program
**Did not consider increased LOCA Bubble loads - this is evaluated in Section 8

8.0 Evaluation of Overstress Conditions Shown in Ref 1.

Reference 1 lists the overstress conditions that were identified in that work. These stresses include increases due to the 2 inch water level increase.

Overstresses Identified in Reference 1 (% over code)

Column to Shell weld	
Inner	32%
Outer	41%
Saddle to Shell Weld	25-62%
Column Anchor Bolts	
Inner	31%
outer	25%
Ring Girder to Shell Weld	
Saddle region	52%
Inner Column Region	72%
Outer Column Region	77%
Monorail	4%
Internal Spray Header	25%
Catwalk	The catwalk is included here, because the reference 1 report did not include LOCA Bubble loads in the evaluation

In this section, we will review each of these using data from this report, as well as other, more recent, data.

8.1 Support System Welds

Reference 1 was based on simple scaling of Mark 1 Program calculations. It showed several overstress conditions in the column, saddle, and ring girder welds. These overstress conditions are similar to those shown in the first estimate of a zero delta P evaluation for Vermont Yankee (Ref 2). The comparison follows:

EARLY STUDIES - % over Code

	JAF	VY
Column to Shell Welds		
Inside Column	32	75
Outside Column	41	65
Saddle to Shell Weld	62	52
Ring Girder to Shell Weld		
Inside Column	72	36
Outside Column	77	96
Saddle	52	117

After these results were calculated, Vermont Yankee chose to do a detailed finite element analysis of these areas, and determined that all of these areas did meet Code with the following margins:

Comparison of Preliminary and Final VY Results

	Preliminary (% Over Code)	F.E.Analysis (% Under Code)
Column to Shell Welds		
Inside Column	75	Not Avialable
Outside Column	65	-10
Saddle to Shell Weld	52	

-36

Ring Girder to Shell Weld

Inside Column	36	N/A

Outside Column	96	-33
Saddle	117	-42

The large reductions in stress due to the detailed F E analysis are not surprising. The Mark 1 Program analysis calculated these stresses with a multi-purpose model that was not well detailed in the weld areas. Since that model produced acceptable results for the Mark 1 analysis, there was no reason to refine it. The model used for the VY FE analysis was much more detailed in the weld areas.

Since the preliminary scaling for the 2 plants produced similar results (with VY generally higher), we can expect a finite element model for JAF to show stress reductions similar to the VY finite element analysis, and we would expect these more accurate stresses would meet Code requirements.

The detailed VY model used as-built weld dimensions taken at the plant - these helped reduce the final stresses. We should do the same for JAF, if we decide to do this more detailed analysis.

Additional Conservatism in Ring Girder to Shell Weld

The detailed VY analysis showed a large reduction in weld stresses near mid-bay in the ring girder to shell weld, as noted above. This was not expected because of the large distance between the added detail near the columns and the mid bay location. This may not happen for JAF.

If a detailed analysis for JAF does not show acceptable stresses in this area, we can take advantage of a significant conservatism in the Mark 1 analysis.

The Mark 1 analysis for this area is shown in ref 4. This shows that the mid bay weld stress is mainly the result of LOCA Bubble drag loads which act perpendicular to the web of the ring girder, and not pool swell shell pressures. In that analysis, this bubble load was applied to only 1 side of the ring girder web, so assumed that drag loads from the adjacent bay were zero - this is very conservative.

If a detailed analysis for JAF shows this weld to still be a problem, we can develop this argument, and should be able to reduce the weld stress significantly.

8.2 Column Anchors

Reference 1 showed an overstress condition for the column anchor bolts for the outer columns, as follows:

Outer column Anchors - 25% over allowable

The column anchors are non-code items and must meet a safety factor of 4 for both full and 0 delta P loads. Load condition 25 will produce the maximum upload on the outside column anchors - this case includes:

LC #25 - 0 delta P pool swell + SRV (case A1.3) + SSE seismic

Reference 1 shows the maximum up loads on inner and outer columns, including the effect of the 2 inch water level change.

Reference 1, page 25 calculates the maximum upload on the outside column for the 0 Delta P load case at 79,542 lbs.. This number was calculated from numbers in reference 4, page 23, which shows it is from a ½ bay model; therefore the full load on the outer column is:

Maximum Upload on Outer Column = 159,084 lbs. 146676 Conservative Due to factors of 2 mirrors 2 non-vent bays 0.922

There is an important conservatism in the reference 4 analysis that relates to the failure mode. The failure that limits the upload capacity of the anchors is a shear failure in the concrete. The reference 4 analysis assumed that the concrete would fail in a shear cone, starting at the top of the wedge device on the anchor bolt - 18.75 inches below the concrete floor . In fact, the failure cone will have its apex at the contact point of the expansion wedge and the concrete, at the bottom of the anchor. Anchor embedment is 24 inches (reference 11, page 8) - this dimension should be used as the depth of the failure cone in the analysis, not the 18.75 inch depth used in reference 4.

Recalculating the shear area of the cones and allowing for overlap produces a shear area of 3073 square inches for 2 anchors, compared to 2047 square inches in the existing analysis (Reference 4). Based on the 2047 area, and allowing for a safety factor of 4, the existing analysis shows a maximum allowable load of 64.5 KIP/anchor. If we scale this number by the increase in shear area, we calculate the allowable load per anchor at:

Allowable load per anchor, including F.S. of 4

3073/2047 (64.5) = 96.8 K/anchor, which includes the safety factor of 4

The column load that must be reacted at each anchor location is 159K/4 = 39.8 K (4 anchors). But the load on each anchor is actually greater than 38.9 K because of the base attachment.

Each anchor connects to the column base by a clamping plate which increases the pull out load on the anchor by a factor of 1.76 (reference 4 page 87); therefore, the load on each anchor becomes 39.8(1.76) = 70 K, therefore;

For the Outside Columns

Allowable anchor load, including f.s. of 4 = 96.8 K
Calculated maximum anchor load = 70 K

The outer anchor bolts are acceptable for 0 delta P operation.

The inside columns have a lower load than the outside columns. The load is calculated in reference 1, page 25 at 56 K/ anchor, for the half bay model, so is 112 K for the full model. This compares to the total load on the outside column of 159 K. The anchors and clamping plates on the inside columns are the same as the outside, therefore the inner columns are also acceptable for 0 delta P operation.

[Note that reference 1 reported a 31% overstress for the inside columns. This was an error as shown above.]

8.3 Internal Spray Header

Reference 1 shows the stress on the internal spray header is 25% over the Code allowable for 0 delta P operation. The primary load on the spray header is the Froth 2 load.

But reference 1 conservatively used a 0 delta P froth load equal to 1.33 times the full delta P load. In this report, that load is shown to be the same as for full delta P (section 7). Based on this, the internal spray header is acceptable for 0 delta P operation.

8.4 Monorail

Reference 1 shows the monorail at 4% over Code. The main load here is the Froth 1 load.

Nicholas Celia, P.E. Consulting Engineer

As in the discussion above, the Froth load used in reference 1 was conservative. It used a 0 delta P froth load equal to 1.33 times the full delta P load. In this report, that load is shown to be the same as for full delta P (section 7). Based on this, the monorail is acceptable for 0 delta P operation.

8.5 Catwalk

The catwalk stresses from the Mark 1 Program are shown in reference 11 page 96, as follows:

	Actual Stress	Allowable Stress
Main Frame	31,500	56,700
Support Columns	42,.765	56,700
Welds at Ring Girder	27,903	42,000

However, page A4.2-48 in reference 11 lists several conservatisms in this analysis. One of these is the use of 0 delta P loads for the controlling load case; therefore, the catwalk is acceptable for 0 delta P operation.

9.0 Evaluation of New ECCS Suction Strainers

New, larger ECCS suction strainers were installed after the end of the Mark 1 Program, using the same design criteria. The strainers are shown in reference 5, pages 13-21. They include 2 RHR, 2 Core Spray, 1 HPCI, and 1 RCIC strainers.

These new strainers were not considered in Reference 1, so must be evaluated here for normal operation at 0ΔP. The loads used in the evaluation of the strainers, and their relative values are shown in reference 8, pages 45-49. These are lateral loads on a typical span of the RHR strainer. The range of loads is:

Typical Strainer Design Loads - lbs/ft

Pool Fallback	4306 - 4851
LOCA Bubble	1913 - 3296
CO	1873 - 2311
CH	1346 - 2017
SRV Bubble	250 - 1320

We will consider each of these loads and changes that might occur for 0 delta P operation, beginning with the largest of the loads - pool fallback.

9.1 Pool Fallback Loads

The controlling load on the ECCS suction strainers is the pool fallback load. The values used in the strainer analysis were for the 1.7 delta P condition. They are shown in reference 5, pages 69-78.

The fallback load only applies to structures above the downcomer exit plane and those structures completely enveloped by the discharge air bubble at the time of fallback. The logic here is that the bubble will displace all the water above the structure and will provide an open space for free fall of the pool to reach the structure. (ref 13).

The fallback load is based on the maximum height of the rising pool over the centroid of the submerged structure, so changes for 0 delta P can be based on this dimension. Reference 6, figures A752-A755 show maximum pool height for zero and full delta P testing. The data shows the maximum pool height at full delta P is 14.32 feet above the center of the strainer discs (RHR and CS), and the 0 delta P pool height is 14.92 feet.

This is an increase of (14.92-14.32)/14.32 = 4.2% in strainer pressure.

The stresses are shown in reference 8 - the minimum margin to the allowable is 6% for the bending + membrane stress in the discs. Therefore, the design can accommodate the added load at 0 delta P with a small margin to spare.

But there are other conservatisms that make this margin larger. Reference 5, page 58 shows the analysis used a Fallback + SRV load case - there is no requirement to combine these loads. The program position was that SRV + poolswell-related loads only were considered up to the time of maximum download . After that, the reactor pressure was low enough that an SRV discharge load would be negligible.

Also, I believe strong, and winnable, arguments can be made that the air bubble could never engulf such large structures, and the fallback load would never act on the strainers at all, especially for the RHR and Core Spray strainers. These strainers are much larger than other submerged structures and the rules should not apply here. In order for Fallback drag to occur, a water slug over 4 feet thick would have to impact the top of the strainer. Since the top of the strainers is 6 feet below the pool water surface, this means that 67% of the water above the strainers would have to re-form into a solid layer of water after bubble breakthrough and formation of the froth load, and then fall almost 15 feet to impact the top of the strainers - this seems impossible. In reference 13, page 75, the NRC states that assuming any solid water slug falling back into the pool is conservative.

Based on this, I conclude the strainers are acceptable for 0 delta P operation, and there may not be any fallback load on them at all.

9.2 LOCA Jet and LOCA Bubble Loads

The load calculations for the new strainers are shown in reference 5. According to reference 5, section 10.0, the LOCA Bubble loads used to evaluate the strainers were conservatively taken at 0 Δ P, so this load is acceptable for 0ΔP operation, without further analysis.

9.3 SRV Bubble Loads

Section 6.7.2 discusses SRV bubble loads at 0 delta P, and concludes this load should be the same as at full delta P. This is true because the bubble load is the result of air clearing from the SRV line, so is unaffected by the difference in the water leg inside the discharge line before the air is forced into the pool.

9.4 CO and CH Loads

These loads will not change at 0 delta P. They are initiated at specific steam flow rates into the pool, so 0 delta P will change the timing of these loads, but not their magnitude.

9.5 Conclusion for ECCS Suction Strainers at 0 Delta P

For the loads used in the reference 8 analysis, the following applies:

Pool Fallback - This load will increase 4.2%, which is less than available margins, so is acceptable. Other conservatisms exist in this analysis that will increase this margin.

LOCA Bubble - The reference 8 analysis used loads developed for 0 delta P, so this load is acceptable.

SRV Bubble - This load is the same at both full and 0 delta P, so is acceptable.

CO and CH - These loads are the same at both full and 0 delta P, so are acceptable.

The ECCS strainers are acceptable for 0 delta P operation.

10.0 Torus Attached Piping

This evaluation did not consider Torus attached piping. The reasoning here is that these systems are accessible, and relatively inexpensive to modify, if required; that is, they would not control the decision regarding a change to 0 delta P operation.

In addition, pool swell is a single pulse, semi static load, so does not significantly excite external piping.

Reference 1 did consider the effects of a 0 delta P change on large bore piping (>4 inch diameter), penetrations, and active components, as they were configured at the end of the Mark 1 Program (1982). That evaluation showed very good results with a few systems exceeding the allowable stresses by small margins. These overstress conditions might be resolved by more analysis.

Many modifications have been made to these systems since 1982, including addition of the ECCS strainers (the penetrations are flexible, so internal and external piping interact). Additional evaluation is required to determine the effect of these mods.

Small bore piping for JAF was not analyzed for pool swell loads in the Mark 1 Program, based on experience with large bore piping; so there is no early work to give guidance here.

The conclusion here is that Torus attached piping should not present a difficult problem for 0 delta P operation.

11.0 Conclusions and Recommendations

Results of the feasibility study are excellent. Almost all of the structures evaluated showed acceptable stress levels for 0 delta P operation; and these were generally based on conservative scaling methods, and conservative loads.

The only areas that showed overstress conditions were the attachment welds for the columns and for the ring girder near the columns and at mid bay. But this was expected. The Mark 1 Program computer model that calculated these stresses was known to be very conservative. A new analysis of these welds, using a detailed finite element model should produce acceptable results.

I am confident of this based on past experience with the same analysis for Vermont Yankee. V.Y. performed a feasibility study for 0 delta P operation similar to this one. The VY study produced very similar overstress conditions for the same welds as shown here (section 8.1). A detailed finite element analysis for that plant showed all welds were acceptable with comfortable margins (section 8.1). I would expect the same results for JAF.

Apart from the column welds, there are no other areas that showed an overstress condition. This includes evaluation of the new ECCS strainers.

External Torus attached piping (TAP) was not evaluated in this study Several modifications have been made to this piping since the end of the Mark 1 Program, so we should expect some modifications may be required here. However, a review of past work on these systems indicates there should only be a few (section 10).

Recommendations for continued work must start with a finite element analysis of the column welds. The work done for VY is detailed in reference 2, and this will provide an excellent guide for construction of the model, and application of loads. Cost of this work requires a detailed proposal, but is estimated here at about $70,000.

Part of the column weld analysis at VY was to perform a field survey of actual weld sizes in the column area for use in the computer model. This should also be done to support development of the new computer model for JAF.

The second most important task to support a decision regarding 0 delta P operation is analysis of the Torus attached piping. Analysis of the modified systems should be reviewed and adjusted for 0 delta P. This should include analysis of the shell penetrations on the Torus, and all piping to the first anchor. It also should include external piping attached to the new ECCS strainers, since the penetrations are flexible and can transfer loads to the external piping.

Part of the piping evaluation should be a review of 0 delta P effects on small bore and branch piping (under 4 inches in diameter). This piping was not analyzed for pool swell loads in the Mark 1 Program, based on the fact that stresses related to pool swell were small - this may not be true at 0 delta P, so an evaluation must be made. However, analysis of small piping was generally done with simplified methods, so reanalysis of these lines should not be a major cost item, if it is required.

A proposal for this work has been submitted at a cost of $12,500.

12.0 References

1. JAF Calculation JAF-CALC-DC-01473, "Drywell to Torus Differential Pressure Study", 3/9/94 Void

2. Vermont Yankee/Altran Calculation for #95215-TR-01, "Finite Element Analysis of Torus Support system without Drywell to Wetwell Pressure Differential", 1/96

3. Teledyne Calc #2386-2, "Fitzpatrick vent header support analysis…", 10/20/83

4. Teledyne Engineering Services Calculation #5321-23, "Fitzpatrick Torus Saddle Analysis", 10/7/82

5. Duke Power Calculation # A384.F02-07, Rev 1, "Fitzpatrick ECCS Suction Strainer Project, 7/28/98

6. GE Report #NEDE-29144P, Volume 3, "Mark 1 Program Quarter Scale Plant Unique Tests", 4/79

7. Letter Reports , Prof Stephen Finch to N. Celia, Statistical Analysis for Single Test Factors, 8/95

8. Duke Power Calculations - stress reports for ECCS strainers
   a. A382.F02-19-r3-680, CS and RHR Strainers, 11/98
   b. A384.F02-19-r1-799, HPCI and RCIC strainers 11/98

9. GE Report # NEDE-24555-P, Volume 3,"Mark 1 Containment Program, Application Guide 10" dated 9/80

10. Teledyne Engineering Services Calculation #5321-36, Rev 1, SRV Quencher and Support Beam Analysis, 4/11/83

11. Teledyne Report #5321-1, Rev 1, Plant Unique Analysis Report …for JAFNPP, Sept 25,1984

12. GE Report # NEDE-23545-P, Volume 3,"Mark 1 Containment Program, Quarter Scale…..Generic Sensitivity", Dec 1978

13. NUREG 0661, "Safety Evaluation Report, Mark 1...Program", July 1980

14. Not used

15. Teledyne Calculation #TG-7" "Presdig Program Check and Input Data Check", 1/17/83

16. JAF Calculation #JAF-CALC-PC-01457, "Torus Level Analysis", 4/5/94

17. Teledyne Letter Report 7543-1, "JAFNPP Power Uprate…", 7/31/91

18. GE Document #NEDO-24578, Rev 1, "Mark 1 Containment Plant Unique Load Definition, JAFNPP" 4/81

19. GE Report # NEDC-32016P-1, Rev 1, "Power Uprate Safety Analysis for JAFNPP, Section 4.1.2, 4/93

IMPERIA REPORT RECORD

Report No.: 13-0541-TR-002 Rev. No.: 1 Page No. 1

☒ 10CFR50, App. B ☐ 21CFR820 ☐ ISO Q9001-2000 ☐ Other: ______ Total Pages: 1

Title: Mark I Program Support to Eliminate Primary Containment Drywell-to-Wetwell Differential Pressure During Normal Operation

Client: Exelon Generation Facility: JAF Nuclear Plant

Revision Description: Revision 1 – Major Revision

Computer runs are identified on a Computer File Index: Yes ☐ N/A ☒

Error reports are evaluated by: ______ Date: ______

Computer use is affected by error notices. No ☐, Yes ☐ (if yes, attach explanation)

Originator(s)	Date	Reviewer(s)	Date
Raymond Pace	8/2/19	Silvester Noronha	8/2/19
		Robert Skwirz	8/2/19

Independent Verification: Performed in accordance with IOP 3.4 as indicated below or ☐ N/A

☒ Design review as documented on the following sheet or

☐ Alternate calculation as documented in attachment or

☐ Qualification testing as documented in attachment

Verifier: Robert Skwirz Date: 8/2/19

APPROVAL FOR RELEASE:

TECHNICAL LEAD: Raymond Pace Date: 8/2/19

Attachment L – Imperia Verification Form

INDEPENDENT VERIFICATION CONSIDERATIONS	Initials
1. The inputs come from an appropriate and controlled source and are clearly referenced.	[initials]
2. The inputs from uncontrolled sources or assumptions are properly justified and documented.	[initials]
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4. Design, analysis, testing, examination, and acceptance criteria are specified and complied with.	[initials]
5. Appropriate interface control was administered during the preparation of this report.	[initials]
6. The computer programs used are authorized for use and/or properly verified.	N/A
7. Applicable codes, standards, or regulatory requirements are properly specified and complied with.	[initials]
8. The specified tests and examinations were performed by personnel with appropriate qualifications.	N/A
9. All tests and examinations were performed in accordance with written procedures.	N/A
10. Samples are controlled by identification number and their traceability is maintained.	N/A
11. The calibration of instrumentation is acceptable and properly recorded.	N/A
12. The instruments that are used are recorded by name and identification number.	N/A
13. The report is neat and legible and suitable for reproduction.	[initials]
14. The formatting and technical requirements of applicable procedures are complied with.	[initials]
15. Numerical computations and use of input data have been checked.	[initials]
16. The endorsements of all Originators and Reviewers are properly recorded.	[initials]
17. Appropriate construction, operation, and/or maintenance considerations have been addressed.	[initials]
18. The conclusions satisfy stated objectives and are consistent with the input.	[initials]
19. All materials specified are compatible with their service environment.	[initials]
20. Procedural requirements for report revisions and subsequent reviews are complied with.	[initials]

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Imperia's Revision 0 of this report was never issued by Exelon as a controlled document in Exelon's Passport document control system. Per direction from Exelon's Jay Ritzel on 8/1/19, the Exelon Generation title block on Page 1 identifies this document as Revision 0. All other revision blocks will show as Revision 1.

Comments were received from J Ritzel on the Draft 0 A issuance to the report on 7/15/19. The completed comment resolution file is stored on Imperia's project file. Minor comments were also received via E-mail on Revision o B from J Ritzel on 8/1/19. These comments were also incorporated into Revision 1 and are stored on Imperia's project file.

All comments are resolved and incorporated except as noted here:
NONE.

Raymond Pace [signature]	8/2/19	Robert Skwirz [signature]	8/2/19
Originator concurrence	**Date**	**Independent Verifier concurrence**	**Date**